A Virtual Reality Tool to Implement City Building Codes on Capitol View Preservation

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Abstract

In urban planning, the urban environment is a very complicated system with many layers of building codes cross-referenced and interacting together to guide urban growth. Especially, if a new urban design is located in a historical area, additional restrictions will be imposed upon regular zoning regulations to maintain the area's historical characteristics. Often, urban regulations read as text are difficult to understand. A tool that generates adequate urban information and a quick visualization of the design will ease decision-making and enhance urban design processes. The goal of this research project is to develop a virtual reality (VR) tool with high resolution, speedy computation, and a user-friendly environment.

This project initiates an interactive visualization tool to enforce city-planning regulations on viewing access to the state capitol building in Des Moines, Iowa. The capitol building houses the Iowa Legislature and is a symbol of state power. Maintaining the view from surrounding areas will preserve the building's monumental and symbolic meaning. To accomplish this, the City Community Development Department and the Capitol Planning Committee developed a Capitol View Corridor Project, which sets up seven visual corridors to prevent the view toward the capitol from being blocked by any future designs. Because city regulations are not easy for the public and designers to interpret and comprehend, this project intends to develop a VR tool to create a transparent environment for visualizing the city ordinances.

1 Background

An urban environment is a very complex system that has many layers of building codes interacting together to guide urban development. Particularly, if a design project sits in a zone with a unique historical context, additional regulations will be enforced over regular zoning restrictions to preserve and emphasize the area's historical characteristics. Codes also vary between city zones. Thus, urban designers and planners expend much effort to find the right codes to meet regulations, especially considering the complexity of high-rise building designs at different geographical locations.

When planners conceive concepts to solve urban issues in the planning and design process, they draw diagrams or build urban models to explore possible solutions and evaluate outcomes. Deficiencies exist in the drawings as well as physical models. For instance, it is difficult to sense the three-dimensional volume through a two-dimensional drawing, and it is impossible to accurately comprehend the proportions of urban spaces, because the scale used in physical models is too small. Thus, drawings and physical models lose details that usually embody meaning and express intentions. Less detail increases ambiguity. Therefore, these conventional presentation tools are not powerful enough to offer opportunities for perceiving interactions that may occur among inhabitants and their surroundings.

A tool that automatically generates urban zoning information and provides an immediate visualization of the design will ease decision-making, enhance urban design processes, and indirectly improve the urban environment. Particularly, the three-dimensional expression of urban codes will turn the legal and technical aspects of planning regulations into transparent visual guidance. A virtual reality (VR) system can serve these purposes. Virtual reality, a highly advanced humancomputer interaction tool (Durlach & Mavor, 1995; Mine, 1995), provides diversified media for an interactive, multimedia experience of activities and behaviors conducted in cyberspace. VR is an excellent tool to visualize objects that do not yet exist. By applying VR, planners and designers will be able to understand spatial qualities of their own designs intermediately. They can comprehend their work by walking through a virtual space to visualize the volumetric impact of the design to the existing space, and the proportions of the spatial layout. Designers can use such an environment as a visualization tool to aid the design process and urban planners can apply it to improve the urban fabric. This project intends to develop a VR tool to make these goals possible.

Advanced virtual reality facilities have been installed in the Virtual Reality Applications Center at Iowa State University. The center uses its state-of-the-art resources to apply virtual reality to engineering and scientific problems. These resources include a variety of computer systems used with wall display systems, head-mounted displays, and interaction devices including stereo glasses, trackers, instrumented wands and gloves, vehicle and aircraft bucks, and a motion base. A number of successful VR applications have been generated in the center, such as architectural design tool (Chan, Hill and Cruz-Neira 1999a, 1999b), architectural reconstruction (Chan, Maves and Cruz-Neira 1999c), virtual prototyping, multidimensional data analysis, and engineering simulations.

2 Concept development

This project is to develop a VR tool for designers, planners, students, and state officials to perceive and manage future urban growth. The process of tool development will rely heavily on technical support from state officials. The relations established between the academy and the public will enhance the outreach aspect of the university. The generated tool from this project will serve as the planning tool for the state government and professional practitioners.

Applying this tool, the public can comprehend the impact of the environment from viewing it through the VR model; designers can input new designs into the tools and plug the design into the model to see through the cityscape how the design meets urban regulations. Planners can examine whether the design violates city codes for issuing building permits. The purpose is to evaluate quickly, easily, and accurately whether a new design located within a particular area meets the urban regulations. This planning tool will be a promising means for controlling the city environment and an efficient instrument for the general public to learn and supervise how public policies shape urban forms.

"*The Iowa Capitol is widely acknowledged to be one of the finest state capitol structures in the United States and one of the nation's great treasures. Its exquisite detail and craftsmanship have been heralded by nationally recognized experts as an incomparable example of period architecture. ... Majestic views of the capitol building from several vantage points in the Capitol City deserve preservation as well. These views not only celebrate the structure's beauty, but also contribute to the unique character of the city, especially as an important symbol for the East Des Moines downtown* (Dikis, 1999)."

The state capitol building sits on a hill on the east bank of the Des Moines River. The geographic location and the contours of the site make the building visible from far away (see Figure 1). This visibility enhances the building's roles as symbol and monument. Because the building houses the state government of Iowa, it acts as a symbol of the power of the state in the urban context. Also,

Figure 1. The state capitol building of Iowa.

since it was built, the form has served as a monument and embodies historical significance. Such a building should continue to stand fully visible in the capital city of the state of Iowa to fulfill its purpose of symbol and monument.

With increased urban growth, such a role of visibility has been challenged. On the west bank of the Des Moines River, high-rise buildings were erected to meet the downtown area's economic development needs. In consequence, the view toward the capitol building has been blocked, which is a critical issue in city planning. To maintain the view accessibility in a particular region (see Figure 2), state officials have been working with the city toward developing a plan that would guide future downtown development in a way that would preserve and enhance the visual prominence of the state Capitol and the character and scale of Capitol Park. Since June of 1990, the city of Des Moines has developed seven capitol view corridors (see Figure 3).

The view corridor is a three-dimensional corridor bounded by prominent public viewing points in several places with a building height restriction imposed to define the sight line to the dome of the state capitol building. A calculation formula for evaluating the height has been established by the city. Special functional purposes are associated with each corridor. In July 1999, the state Legislature authorized the city to enact zoning regulations to preserve the dominance of the capitol building dome and the view from prominent public viewing points.

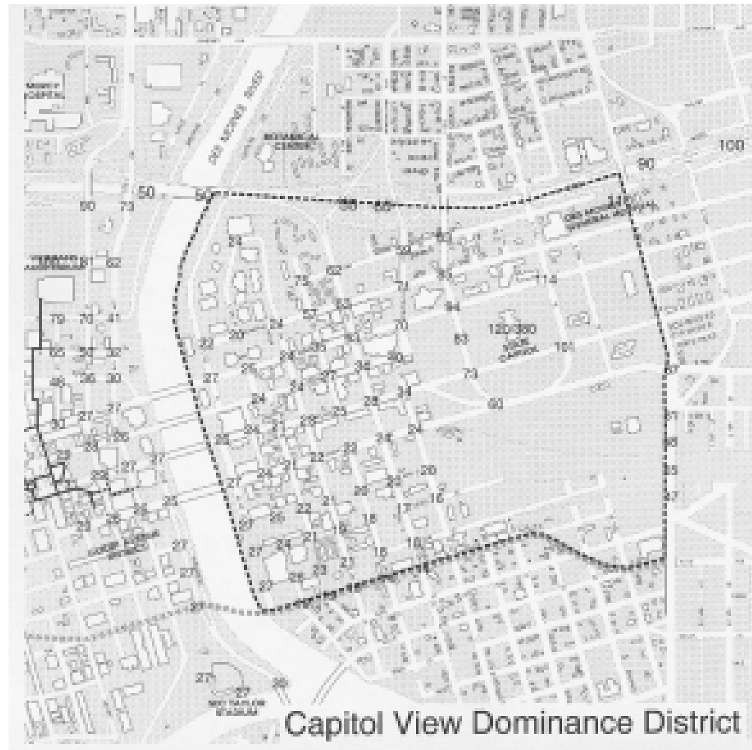

Figure 2. Capitol view dominance district.

According to the building codes, any new designs located within these corridors will have a specific building height limitation and setback requirements. For instance, the limitation on the Second Avenue/Freeway corridor #4 is restricted to 225 feet (see Figure 4) toward the base of the capitol's beautiful golden dome, and differs from the 194-foot limitation on the East 15th Street/Freeway corridor #2 (Figure 5). The seven corridors have different sets of height limitations ranging from 80 feet to 450 feet.

The height of the building is determined by the formula of $H = (\tan\theta \times B') - E$, where H is the building height on site, θ is the view angle from the viewpoint at a child's-eye level of 33", B' is the distance from viewpoint to the site, and E is the result of subtracting viewpoint elevation from site elevation (see diagram shown in Figure 6).

Currently, the conventional way to test whether a design meets the view regulation is to examine drawings, physical models, or digital models constructed by the designers. Economically, it is an expensive and very time-consuming process. Regarding perception, viewers cannot share a mutually inclusive view of the results. Therefore, the tools and methods for presentation need to be improved to provide an accurate, efficient, and easily understood result. This project will build a digital model of the east bank of the Des Moines River to represent the buildings three-dimensionally in a virtual reality environment. Then, the building height formula and associated city regulations together will be converted into

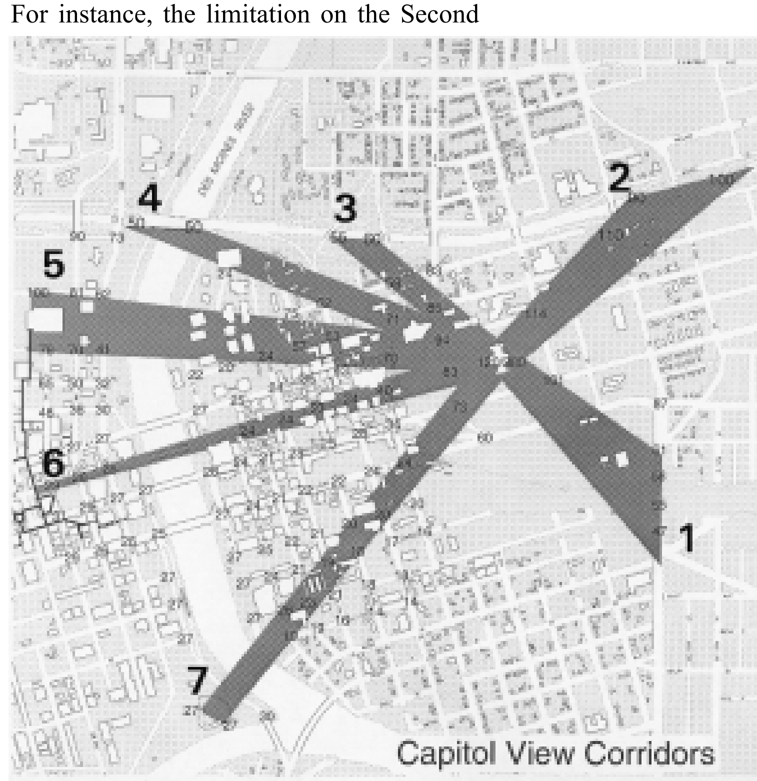

Figure 3. Seven capitol view corridors.

computer source codes implemented in a digital city model. The digital model is constructed by a CAD system. The center of the model is the capitol, which is surrounded by seven conceptual corridors with various height regulations. Thus, different functions and algorithms are installed to establish the basic structure of the tool.

Methods of evaluating the building height restrictions of each corridor will be executed by animation, navigating from the beginning of the corridor to the dome of the capitol building. Animation is utilized by installing navigation paths along a child's-eye level to test the view accessibility. If the dome of the capitol cannot be seen at a child's-eye level, then a height violation exists and the design must be revised. The entire tool, after completion, will be converted into Virtual Reality Modeling Language (VRML) models and displayed on the Web for public access. It is hoped that designers can submit and plug their design projects into this VR environment and through animation, evaluate whether the design meets city codes.

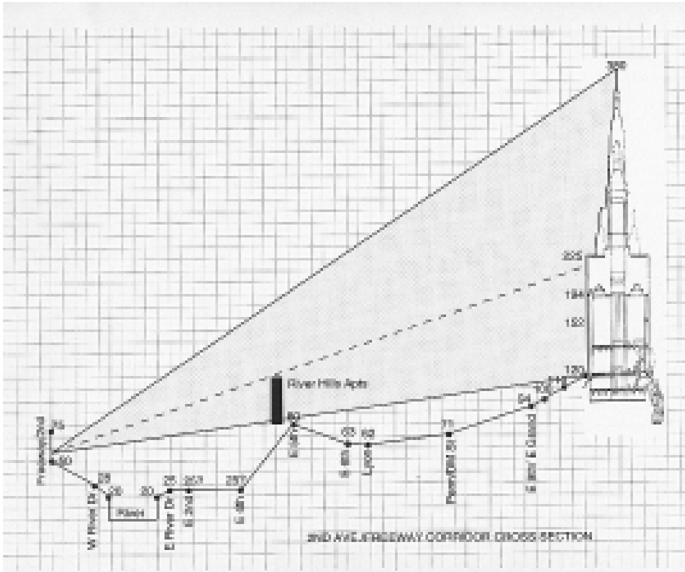

Figure 4. E. 15th/Freeway corridor #4.

3 Methods of tool generation

Tool-generation methods include digital modeling of the city in the VR environment, converting urban codes to computer codes, embedding these codes within the VR model components, and creating a user interface between the model and codes. The digital city model will be generated by AutoCAD on PCs and MultiGen Program on SGI platform. Modeling information is based on drawings provided by the city (see Figure 7) and photos taken on the site.

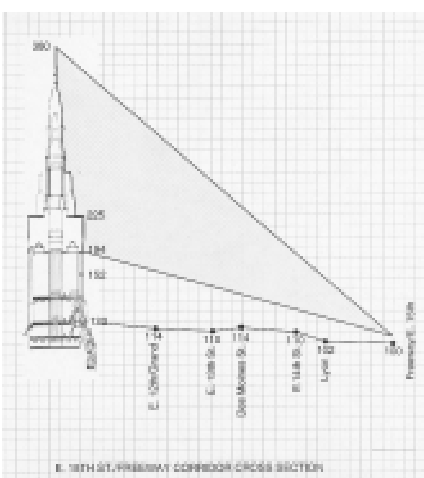

Figure 5. Second Ave./ Freeway corridor #2.

The model will have schematic representation of the body of buildings locate within the corridor. The roof shape of each building will be constructed in more detail than the body part. Inside the MultiGen model, animation paths for each view corridor will be defined by a series of algorithms implemented by VEGA — a MultiGen Application (API) package executed in the MultiGen environment and displayed through the Performer. A number of paths would be assigned in each corridor, starting from certain prominent viewpoints toward the dome.

4 Current progress

The project is in the starting stage and the work is on constructing wireframe representation of the state capitol, the capitol park, and the surrounding blocks. After the skeleton of buildings on blocks is completed, a first animation will be encoded, installed, and tested. This article is a working paper. Some high resolution of the image will be completed for presentation in the fall of 2000.

At this stage, corridor #2 is the focus. Corridor #2 can be called the I-235 corridor, which is tightly connected to a highway reconstruction project supervised by the Iowa Department of Transportation. The IDOT developed an I-235 Master Aesthetic Plan for evolving planning and design ideas for the transportation corridor. Conceptual ideas for the aesthetic elements of Interstate 235 have been addressed, which include roadway landscape development, vehicular and pedestrian bridges, and functional structures related to roadway development, e.g., retaining walls, roadway lights, etc. One of the suggested goals is to showcase Iowa's capital city and its resources. Therefore, the view corridor #2 is responsible for preserving the capitol view from the highway.

Figure 8 shows the topography of the corridor area. Figure 9 displays photo animation of the highway westbound. Figure 10 demonstrates AutoCAD wireframe animation viewed from the highway to the capitol building.

5 Expected final results

Four products of the tool will be generated. The period of time needed to complete each product varies, and each product is a continuous effort.

- A VR tool equipped with the digital city model, and a set of databases containing urban codes implemented by C++ and interacted with users through head-mounted display (HMD). To view a VR model through a HMD, a MultiGen digital model should be converted into the Performer environment. This is the primary version of the tool that runs on Silicon Graphic machines. The time frame for each corridor is scheduled as two months of modeling and two months of setting up the corridor boundaries, codes for height, and defining paths for animation.

- A PC version of the tool will be converted from the MultiGen model into an AutoCAD/MAX model. Its urban codes and user interface will also be executed by animation in MAX. This low-end version is developed for design practitioners and small firms using PCs. The generation of this product is feasible, because there are import and export functions shared by AutoCAD, MAX, and MultiGen software to make a digital model mutually compatible. Each corridor will require a two-month effort to (1) convert models from MultiGen into ACAD/MAX, (2) polish the model in MAX after transforming the file, and (3) develop MAX key frame animation.
- A VRML model of the tool will be converted directly in MultiGen and displayed on the Web for public viewing. This VRML model will have default animation to simulate the view corridors. The expected time frame for each corridor is one month for converting plus setting up the pages on the Internet.
- The MultiGen model will be converted into a new version of a CAVE model (advanced version of the Cave Automatic Virtual Environment, or CAVE facility) to create an immersive VR projection for full-scale perception. The newer CAVE facility, C6, available at the Virtual Reality Applications Center (VRAC), is a synthetic (Cruz-Neira, Sandin and Defanti, 1993) environment providing a full-scale setting for image projection and perception. C6 is one of only four six-sided rear-projection VR display facilities in the world at this time.

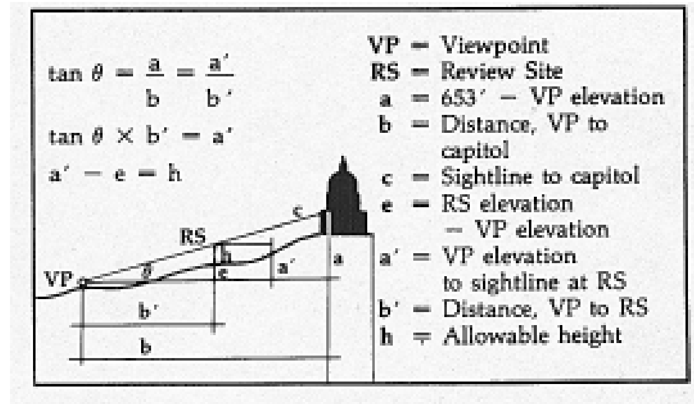

Figure 6. Capitol view preservation height calculation formula.

Figure 7. Digital map of the capitol park.

Ultimately, a virtual city is created. Users can tour the city, select a building in a particular corridor to study its regulations, or replace a building with a different one on a particular site to evaluate the related city codes in PC version or SGI version. Designers also can view the city and obtain planning information through the Web. Thus, this is a generative and/or evaluation tool.

6 Methods and procedures of tool generation

Unlike any other development of a virtual reality city or historic building in cyberspace, this is a VR tool for planners and designers to interact with the urban form. Bill Jepson and his urban simulation team at the UCLA Urban Simulation Laboratory are constructing the city of Los Angeles. Within the virtual city, users can walk, drive, or fly through (Jepson and Friedman 1998). Similar projects on modeling historic buildings can be found in Chan, Maves and Cruz-Neira (1999), whose work produced models representing seven historic architectural styles. Applying the knowledge and similar techniques from precedents, this project intends to show the feasibility of developing a tool to help city planners manage the future environment of a city.

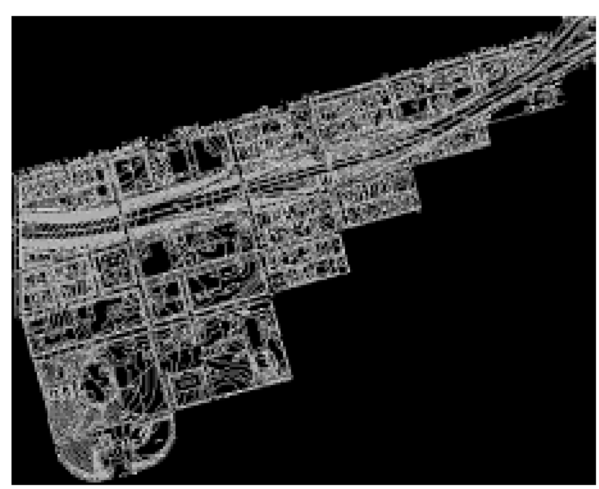

Figure 8. Topography of corridor #2.

There are future advantages and possibilities resulting from this project. Converting urban codes into

Figure 9. Photo animation.

computer codes has rarely been done in the field of urban planning. The algorithms and subroutines developed in this tool can create a new area of research. The digital city model and its associated planning data can assist efforts at simulating public transport, evaluating the traffic environment, designing for modality, developing strategies for urban management, controlling environmental pollution, increasing tourism, studying cultural heritage, and conducting urban renewal case studies, among others.

7 Future directions

The city model will be expanded to also cover the opposite bank of the Des Moines River to complete the entire capital city of Des Moines. Using this as a starting point, the model can be further developed to simulate the entire city planning ordinances. It has several future potential benefits to a number of user groups as described in the following:

- Designers, contractors, and city planners can use this tool to guide urban form. Many interrelated aspects of the urban environment, from transportation and mobility to social elements, can be tested in the database and allow users to visualize the result immediately.
- For city planners and administrators, it can be used to guide urban growth.
- For students in academic institutions, it is a tool to study the relationship between codes and forms.
- For citizens, it is a way to visualize, understand, and supervise public policies — it can be used as a complementary public-hearing tool.

Results collected from this project will extend our understanding from urban planning to information technology and from modeling to systematic encoding of urban regulations. The efforts will set up a new initiative for the application of VR information science to the planning and design professions, a new tool that hasn't been created or implemented before. Methodologies gained from this project will be simultaneously applied to develop a planning tool for the capital city. This project is significant to help visually implement the city ordinances starting from view protection. Applying the same city model, other city ordinances can be further installed to serve as a planning tool for the public, a learning tool for students, and a guarding tool for the state planning officials.

Acknowledgements

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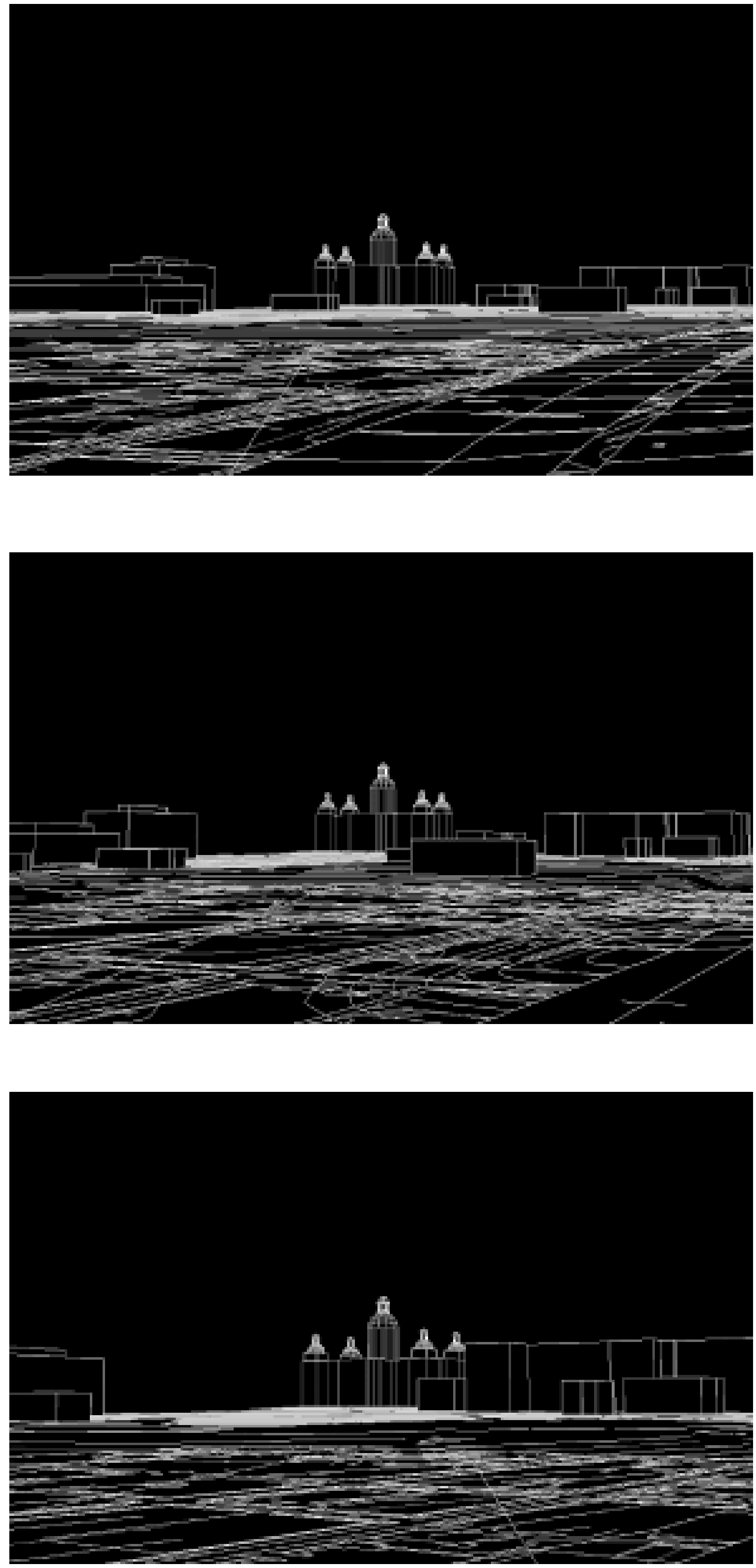

Figure 10. Wireframe animation.