

**WHERE VIRTUAL MEETS REALITY:  
EMPOWERING THE PUBLIC WITH TANGIBLE AND DIGITAL VISION BUILDING TOOLS**

by

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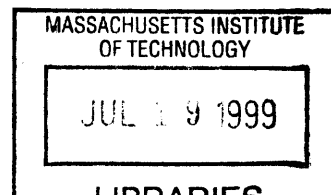
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**ABSTRACT**

Neighborhood community organizations that strive to incorporate the public's ideas into designs and plans have needed more appropriate tools for vision sharing. This thesis described one possible approach for improving the public's ability to design, share, and evaluate alternatives. In the past, the public's primary role during neighborhood design meetings has been that of 'evaluators,' critiquing those designs that were presented to them. This research attempted to illustrate how new and emerging information technology tools could potentially empower the public with the ability to visually express their own design ideas and visions for their neighborhood, shifting the public's role from that of strictly 'evaluators' to that of 'co-constructors.'

The strategy presented for vision creation included both a tangible, model-making framework and a digital, virtual reality component. Residents at a public meeting would start the visioning process by 'playing out' their ideas using physical LEGO™ blocks. The intuitive and simple tangible interface of LEGO™ blocks encourages a constructionist approach toward thinking about urban design issues. Software tools were prototyped to augment the physical model creation and vision sharing process. An object movie, authoring tool was prototyped to digitally archive physical models. A virtual reality, authoring tool was prototyped to allow remote users to also participate in the design process.

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*Dedicated to my parents,  
Edward and Audrey Schweibinz*



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## **INTRODUCTION**

### **PROBLEM DEFINITION**

Many neighborhood-based community organizations recognize the importance of involving the public in every phase of their work. The residents of a community often have rich information about their neighborhood, and their insights can be extremely valuable. However, taking advantage of the public's knowledge is not as straightforward as it might seem. Many challenges exist for community organizations that wish to tap into the knowledge bank of the neighborhood residents.

This research presents a strategy for community organizations to incorporate a new kind of planning support system into the visioning process that might take place during a community meeting. The software tools that were developed have the potential to help residents better define, share, and evaluate visions for the future re-development of their neighborhood. The tools help address some of the challenges associated with participatory planning, while remaining affordable for most community organizations to implement with modest budgets and computers.

### **PARTICIPATORY PLANNING CHALLENGES**

Many planning situations involve multiple stakeholders. Each participant may enter the visioning process with a very different conception of the present conditions of the neighborhood. Therefore, the initial challenge for any participatory planning process is

to first establish a common understanding of the problems and strengths of the community. Sharing perspectives will help everyone that is involved better understand the full scope of the issues.

Sometimes, stakeholders will join the planning process at different times. Often, those joining late can benefit from knowledge about what has happened in the past. Thus, bringing new participants up to speed on the group's past happenings is important for developing a shared knowledge of the direction a community is heading. Record keeping of ideas, debate, and decisions is an integral but often underutilized element of planning discussions.

A related challenge is eliciting the participation of all the potential stakeholders. Many planning activities happen in a 'same time, same place' mode. In other words, the participants must be present at the same time and at the same place for collaborative work. Some stakeholders inevitably will be left out of the planning process because of scheduling conflicts and other commitments that prevent them from attending planning meetings. Thus, creating multiple entry points for participation becomes important.

Even when the majority of the stakeholders are represented, the challenge of getting the participants to 'speak the same language' exists. Diverse communities may have several different languages spoken. Cultural barriers within a community may make it difficult for communities to collectively communicate their visions with one another. It is not enough to rely on the planning team or consultant to take on the onus of interpreting

numerous visions and stories people bring forth. Rather, the community members themselves must come to try and understand their fellow residents as best they can.

The multiple languages challenge does not just include a direct interpretation of ‘speaking the same language’ such as speaking English as opposed to Spanish. This challenge also relates to the use of uncommon technical terms within discussions. For example, a transportation planner might speak of Level of Service (LOS) measures describing the traffic conditions of a particular street, yet the general public might not understand what this measurement really means without a corresponding visual representation. [Shiffer, 1995].

A related problem associated with language barriers is the imbalance of access to tools for conveying and expressing one’s visions for a place. For example, an architecture firm might have the technical savvy, resources, and time to build a photo-realistic CAD model of a development project. Such a model might be very persuasive in conveying that firm’s ideas for the future development of a place. However, one wouldn’t expect members of the general public to have equal access and skills to manipulate and alter high-end CAD models. Even when a CAD designer returns to the firm with the public’s feedback on a design, a barrier still exists between the public and the design that may lead to misrepresentations of the public’s ideas. In fact, many forms of representational aids end up serving a presentation-only purpose that is difficult to modify in real time, preventing the easy incorporation of the public’s ideas and feedback. Thus, the ability to



provide the public with direct access to the design through the use of a common, easy-to-operate toolkit remains an important research challenge.

## **TRADITIONAL TOOLS FOR VISION-SHARING**

Discussions around the future vision of a neighborhood can happen in several ways. One method might be to ask all the residents present at the meeting to close their eyes and think about a place that they have fond memories of. Next, the planning team might elicit verbal descriptions from each of the residents about what exactly it was about those recalled places that made them fond memories. Was it the people they were with? Was it the weather? Was it the lack of traffic? Was it the serenity of the place? Was it the smell of the flowers? Identifying the characteristics of places that bring fond memories to people can be helpful for some situations when brainstorming about how to improve one's neighborhood. However, the sharing of ideas and memories can be difficult when the process is strictly a verbal exchange.

Having small teams of people surround a map and mark up the map with their ideas is another technique for talking about a place. A map provides a spatial reference point around which discussions can follow. Depending on one's familiarity with a place, the map can help a person mentally recall parts of town as a discussion changes focus.

Marking on a map provides interaction and persistence to the flow of a discussion.

Thoughts are recorded, and the map can be quickly filled up with ideas. The flow of the discussion is not necessarily preserved, as all ideas fill the same 2D paper-space.

Nevertheless, a record of some sort is created with a tangible, marked and highlighted map that can help future discussions.

Some communities have the luxury of working with a scaled, wooden or plastic model of their neighborhood. These models can help residents think about and discuss the placement of buildings in relation to each other and in relation to different land uses. The models offer a 3-dimensional perspective that helps people visualize the bulk of the buildings, the relative heights, and the relative densities. Discussions around scaled models tend to include pointing and speaking about modeled objects, grabbing and touching the objects, and possibly moving or rearranging objects to new locations.

Several constraints exist when working with a scaled model for collaborative discussions. First, the interaction generally lacks a history that can be followed. Most often there is only one complete model, and as it gets rearranged, the previous state of the model is lost or forgotten. Comparisons between one arrangement and a previous design are difficult since two or more complete models are rarely available and any comparison must result from memory of the previous state. Often the original state of a model is recorded through painted building footprints on the surface of the table on which the model is placed. This record is useful for getting things back to the way they were, but isn't very useful for exploring the iterative changes that might be discussed over time.

A more sophisticated setting might include video footage, artist's renderings, and pictures generated from Computer Aided Design (CAD) models. While each involves a less

abstract vision for the community, these and other media tend to be much less interactive for the public to make changes to. The public may have the opportunity to verbally evaluate the various media rich presentations, but producing new video clips or editing a CAD model generally are beyond the scope of the feasible interactions during a community visioning meeting.

### **EMERGING TECHNOLOGIES FOR VISION-SHARING**

Computer-based technologies offer potential enhancements to the participatory planning process. For one, technology allows for a 'different place, different time' mode of discussion [Shiffer, 1999]. Stakeholders can discuss a project via the Internet at times convenient to their own schedules, leaving comments asynchronously for each other within a shared web space. Computers can help organize and archive discussions, allowing new stakeholders to quickly bring themselves up to speed on the past and present directions of the planning process.

Virtual reality tools promise to be the next generation standard for visualization and simulation. Virtual reality is the most immersive of multimedia technologies, allowing a user to experience a place through many different senses, such as vision, sound, and touch. Other, less immersive forms of virtual reality still offer useful and compelling visual experiences. Advancements in technology that make virtual environments more interactive promise to benefit the public, allowing them to manipulate and change the environment virtually in order to represent their individual visions for the future design of

places. Combining interactive virtual design environments with asynchronous communication channels provides a useful model for new tools designed to aid the participatory planning and design process.

Introducing computers into the visioning process, however, is not without its own challenges. Many people still today have little experience with computers. Participatory planning by its very nature strives not to exclude people from the planning process. Some people will find computers intimidating, and where they might otherwise participate, some people may find themselves retreating to avoid embarrassment or difficulty using the computer. A technology-enabled, participatory planning strategy must be as simplistic and unthreatening as possible in order to facilitate the most involvement.

Public access to technology is not completely outside of the scope of this work. The public must have Internet access to make use of some of these asynchronous communication channels and tools. In fact, access to technology is recognized as one of the critical factors for a successful planning support system. The general premise is that the tools developed as a part of this research will be freely available via the Internet to anyone who has access to the Internet. Planning bodies that choose to use such Internet-enabled tools should also strive to maintain other entry points for participation. This research is not intended to shift the entire planning process into the virtual realm, but rather to provide an additional channel for the incorporation of new ideas and to empower more people with the ability to visually express their visions.

Community members need tools to share their visions for redevelopment. Visualizing the future within a public forum requires the ability to express one's vision in a way that others can comprehend. Without the proper tools for vision sharing, a community risks adopting a plan that does not properly address the public's needs. These plans might fail either politically, by not having the public's full support, or functionally, by not addressing the public's needs. Vision sharing also implies methods for evaluating and expanding on alternatives within a shared context. Employing emerging interface technologies can augment traditional visioning exercises about the future of the built environment. In particular, these tools provide a common base for discussion, vision sharing, and evaluation of alternatives.

### **RELEVANCE TO PLANNING**

More and more attention in planning theory is given toward the importance of the public interest. [Campbell, 1997]. Empowerment planning, for example, attempts to provide citizens with the means to make their own planning decisions. This research recognizes the importance of the public's role in planning and designing their own community. In the next section, I present relevant trends and research in both empowerment planning and planning support systems. Next, I suggest some potential improvements for enhancing planning support systems and empowering the public.

It is important to note that the tools developed for this research are not meant to solve all of the difficulties of participatory planning in one falling swoop. The intention is to provide simple design tools that the public might use to help visually express their knowledge and desires for the re-development of a part of their neighborhood. Important to the concept of these tools is the ability for people to not only express their own visions, but to review and evaluate the logic behind other people's stories and visions.

## **LITERATURE REVIEW**

### **EAST ST. LOUIS ACTION RESEARCH PROJECT (ESLARP)**

The East St. Louis Action Research Project (ESLARP) is a national model for a successful participatory and empowerment planning philosophy<sup>1</sup>. The residents of the community set the entire research and technical agenda of ESLARP. At one point, the community decided it needed a playground for young children. Emphasizing the participatory philosophy, the children themselves designed the future Illinois Avenue Playground. Interestingly, during the design process, one child continually insisted that a bench be placed right in the center of the action of the playground. The visiting student volunteers questioned this design, arguing that parents wouldn't want to sit in the heart of the playground, but would rather sit near the less active periphery. The child was determined, however, to place the benches in the center. When asked why, the child told the students that the only way his grandmother would ever let him play at the playground was if she could see everything that he was doing. Hence, the placement of the bench in the center. The relevant lesson is that empowering the public, including children, has the potential to lead to better plans and designs.

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<sup>1</sup> Internet website for ESLARP project is <http://www.imlab.uiuc.edu/eslarp/>

## **MULTIMEDIA REPRESENTATIONAL AIDS**

A central aspect of the participatory planning process is the exchange of ideas. Planning support systems have been useful in supporting this rhetoric. [Shiffer, 1999]. In particular, collaborative systems help people work together more efficiently. Multimedia representational aids can be used to help people recall and describe places within the built environment. For example, digital video clips and other images of places throughout a neighborhood can be hyperlinked to a map within a planning support system. The system can then playback related images when queried within a meeting setting. The visual aids help people recall images of the neighborhood during their discussions. The ability to establish a well-known, common context allows planning discussions to focus on more meaningful issues such as speculation about the future design of a place.

Other systems have been designed in the past for virtual navigation, such as the Aspen project. [Mohl, 1981]. Video sequences were collected from cameras attached to the roof of a car driving through the streets of Aspen. Using laser disc technology, the virtual navigation system allowed users to replay the drive around Aspen. Users of the system could dynamically choose which way the vehicle would turn and the associated video clips would load into the display. This virtual representation recreates a scene, in this case the streetscape of Aspen at a particular moment in time. These types of systems are well suited for recalling images of a neighborhood, but do not provide the necessary tools to visualize the future design of a place.



Some recent research has begun to allow people to annotate maps in new ways to convey ideas. Carleton Tsui developed a system for annotating maps with multimedia objects. [Tsui, 1998]. The system allows one to query a particular viewpoint on the map and retrieve all the related multimedia objects that fall within a viewshed. The functionality for users to add their own pictures and other multimedia objects into the system is an important step in creating interactive support systems and documentation tools. Tsui's system differs from many multimedia-based systems in that it is both an output and an input tool. In other words, users can not only query the system for images and other multimedia objects, but can also add to the system their own multimedia information. This two-way interaction, while more complex to manage as a database, can potentially provide a more content-rich system that can change over time.

A growing number of multimedia capture devices are becoming Global Positioning System (GPS) enabled. GPS can help identify the coordinates at which photographs or video have been recorded, which helps link the images to a spatial database or map. Systems have been designed that encourage children to share their GPS-recorded digital images of places they have visited. [Smith, 1999]. As spatial multimedia databases expand in content, the ability to use these systems as design and visioning tools grows. One might imagine in the future a person being able to express their vision to others at a meeting by assembling a collection of multimedia objects, possibly collected from places around the world, that share the characteristics of that person's own vision for their neighborhood.

## VIRTUAL ENVIRONMENTS FOR PLANNING

Research into the use of virtual reality for city planning has also been gaining interest. William Jepson, of UCLA, has developed a Virtual LA, a photo-realistic computer-based model of Los Angeles, California. [Jepson, 1995]. Using texture-mapping techniques, Jepson's Virtual LA maps photographs of buildings onto basic geometric shapes representing buildings. The end effect is a compelling model of Los Angeles in which a person can simulate real-time navigation throughout the virtual city. The process of collecting the photographs and building the model takes approximately 40 working hours per square block of Los Angeles for a team of four research assistants. Companies such as Planet9 Studios<sup>2</sup> help make the process of creating virtual city models faster by offering customers rough three-dimensional digital datasets of building cover within several major cities. Other companies, such as the Japan-based company Gentech<sup>3</sup>, are developing tools to process orthographic photos and reconstruct three-dimensional, texture mapped city models.

As the technology becomes cheaper, and new methods for compressing and streaming virtual environments become reality, systems like Jepson's Virtual LA will be extremely valuable for design-related discussions and visualization. However, until that time, such systems tend to only run well on very expensive, high-end graphics workstations, making them impractical for community based organizations with limited resources. Also, bandwidth limitations make it difficult for the general public to access an extensively texture-mapped virtual environment from remote locations via the Internet. While the

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<sup>2</sup> Internet website for Planet9 Studios is <http://www.planet9.com>

Virtual LA project can help a community visualize places, manipulating the model and generating alternatives still largely remains in the hands of the computer programmer, not the public.

## **POTENTIAL IMPROVEMENTS**

Many electronic representational aids and virtual environments help the user get a sense of a particular place, but fall short on providing the user with the means to design and alter the representation. As described in a previous section on tools used during traditional collaborative planning meetings, the hardcopy map or scaled physical model often end up as the gathering point around which participants discuss their visions. The map might be physically marked up with ideas, and the model may take on different arrangements when discussing alternatives. A planning support system could incorporate the physical interactions that make the hardcopy map or physical model such useful tools, while adding the computational power and record-keeping abilities of modern information systems. Creating better interactive tools and interfaces for incorporating users' input and designs are the logical next steps for planning support systems that strive to facilitate a participatory planning process.

Providing the tools to alter and amend a virtual environment is not enough, however. The system must also be designed to document and share each participant's designs with one another. As a part of this collaborative online design environment, users should be able to expand on other users' concepts and designs. The ultimate goal is to incorporate

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<sup>3</sup> Internet website for Gentech is [http://www.gen.co.jp/home\\_e.html](http://www.gen.co.jp/home_e.html)

the best ideas from a range of participants into a few good alternatives. The system might include a ranking system for the democratic determination of which designs are best.

Participatory planning by definition calls for participants. Creating an online-element to the design discussion can potentially help the participatory planning process reach a wider audience. In addition to broadening participation, an online design environment attempts to fill a void in the lack of publicly available tools to aid in visual expression of creative ideas.

### **TANGIBLE USER INTERFACES (TUIs)**

Incorporating useful technology does not necessarily mean participants are stuck designing with a mouse and keyboard. Recent technological advancements in the domain of tangible interfaces have inspired much of this work. [Ishii, 1998] Tangible interfaces capitalize on people's strong skills for sensing and manipulating the physical environment. By coupling physical objects with digital information, tangible media allow for new types of human computer interaction. Developments in tangible user interfaces (TUIs) have the potential to make access to digital information more efficient and more intuitive.

The metaDESK is one of the few tangible interface systems with a specific application for urban planning, called Tangible Geospace. [Ishii, 1997]. The metaDESK consists of

a back-projected, nearly horizontal display made into a desk, an arm-mounted flat-panel screen, and an optically transparent lens like surface that the desk display projects through. The Tangible Geospace application allows the user to place physical icons, or phicons, such as model buildings onto the desktop surface and manipulate the buildings in ways that change both the desktop display, and the arm-mounted flat panel display. For example, when a model building is placed onto the desktop, an orthophoto scaled to fit the footprint of the physical building is generated on the desktop display. A corresponding 3D model of the area is rendered on the arm-mounted flat-panel display. When the user adds a second building, the user can rotate and scale both displays by rotating and moving the models with one's hands.

The metaDESK and the Tangible Geospace application put the control of the computer literally in the hands of the user, exploiting the more natural interface of moving objects around physically. The Tangible Geospace application aids in navigation and recollection of spatial information. The system, however, is less useful for designing new alternatives, since the blocks placed on the desktop must be pre-registered with the system and manipulations of the blocks show a predefined 3D environment. The specialized hardware and software needed to implement such a system could make this type of planning support system impractical for many neighborhood organizations looking for more simplistic tools for aiding their visioning process.

While the metaDESK may seem out of reach for the low-budgets of neighborhood organizations, thinking about these new research developments in the eye of ever

improving technologies that are growing more affordable every day is still useful for this research. The metaDESK and Tangible Geospace applications could be developed further to provide capabilities for constructing new design alternatives using phicons. Another promising development also from Ishii's Tangible Media Group is a tangible interface called Triangles. [Ishii, 1998]. Triangles are hand-held plastic devices with magnetic edges that are used to connect Triangles together. Each Triangle has a microprocessor on board which when connected to another Triangle, can electronically communicate both with a computer and with the other Triangles. Triangles keep track of adjacency and positional data such that a computer can reconstruct the geometry that a series of connected Triangles might form. One might imagine extending this technology into the urban design process by allowing users to rapidly prototype designs for their neighborhoods using graspable physical objects that can communicate their design into a computer for further analysis or incorporation into larger digital models.

## **THEORETICAL REVIEW**

This research stems from broader theoretical backgrounds which have helped me think about the appropriate role technology might have in aiding a community-centric design process. Kevin Lynch's writings on the Image of the City played an influential role in my thinking about the appropriate functions a virtual image of a city might incorporate. [Lynch, 1960]. Seymour Papert's educational philosophy known as 'constructionism' served as an appropriate basis for the rationale for turning the public into designers of their own community. [Papert, 1980]. Lastly, Joseph Wresinski's preaching of the importance of 'reciprocal learning' underlies much of this work. [Tardieu, 1999].

### **IMAGE OF THE CITY**

Kevin Lynch's *Image of the City* provides an appropriate entry point for discussions on the role of virtual cities or parts thereof. Image formation relates directly to urban cognitive map formation. A more complete cognitive map of a place helps a person get more out of her city. A virtual representation of a portion of a city provides the person with an immediate tool for better understanding a place through query and exploration. Besides using virtual environments to expand one's own image of the city, virtual environments can be used to help a person understand other people's images of the city. Used in this way, a virtual environment can serve as a forum for discussion about the multiple perspectives that individuals experience within the same place. Discussion over

these multiple realities helps to create a common understanding of the strengths and weaknesses of places.

## **CONSTRUCTIONISM**

Seymour Papert's theory of 'constructionism' is an educational philosophy that people (in his studies children) learn by building things. In other words, people must be active participants in order to build new ideas. In addition, Papert argues that people construct new knowledge better when what they are engaged in is personally meaningful.

Employing this philosophy, a design process that allows the public to try out and physically build their individual and group visions can help create a collaborative atmosphere for public evaluation of alternatives. The more personal interest a stakeholder has in a planning situation, the more attuned that person will be for constructing new knowledge of alternative designs.

## **RECIPROCAL LEARNING**

Joseph Wresinski's 'reciprocal learning' theory is simple but of great importance. The basic idea is that good things will happen when people communicate and expect to learn something from one another. Planners, therefore, should not expect to just teach the public about planning concepts, but should also strive to learn from the public. An environment built on mutual learning is open to idea generation and exchange and provides for an appropriate forum within a participatory planning context.



## **STRATEGY FOR A FUNCTIONAL PROTOTYPE**

### **GENERAL GOALS**

A goal of this research has been to develop some new tools for augmenting traditional visioning exercises that may take place during community meetings. Both physical and virtual based tools have their advantages and disadvantages. Physical based tools, such as scaled wooden models and hardcopy maps allow people to focus on tangible, spatially representative objects while providing intuitive interaction through grabbing, moving, circling, pointing at, and marking objects during a discussion. Virtual tools can be beneficial by providing archival capabilities, greater realism through video and other images, and tools to compare and examine alternatives. In the next several sections, a strategy for incorporating useful elements from both physical and virtual based tools is prototyped.

### **LEGO™ BRICKS AS A PHYSICAL DESIGN TOOL**

LEGO™ bricks are small plastic toys, often in the shape of blocks, which snap together to form larger structures. These popular toys can help people quickly assemble abstract models of buildings, streets, and other neighborhood features. These models can then be used to think about a particular design situation in a tangible way. LEGO™ models differ from models constructed from wood as they can easily be disassembled, reassembled, or expanded.

The LEGO™ Group<sup>4</sup> estimates that 203 billion LEGO™ elements have been moulded between 1949 and 1998. Thus, it is fair to assume that LEGO™ bricks are widespread and familiar to most people. LEGO™ bricks also offer quick alternative generation. For example, there are 102,981,500 different ways to combine just six 8-stud bricks of the same color.

### **LEGO™ ELEMENTS AS A VIRTUAL DESIGN TOOL**

LEGO™ models might be used in a virtual setting for sharing, discussing, and developing design concepts. While graphics workstations can support the photo-realistic modeling of cities, several reasons exist for opting for a less realistic modeling environment. The next few paragraphs outline the rationale for developing a collaborative design tool around abstract LEGO™ representations.

First, LEGO™ bricks are widely available and relatively inexpensive. Thus, it would not be unreasonable for a neighborhood organization to amass a large collection of blocks that could be used during a design charette. As this research will show, some of the benefits of tangible interface technology can be achieved without even embedding a technological component, such as sensors or microprocessors, into the LEGO™ blocks. Thus, costs are kept down.

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<sup>4</sup> The Lego Group website address is <http://www.lego.com>

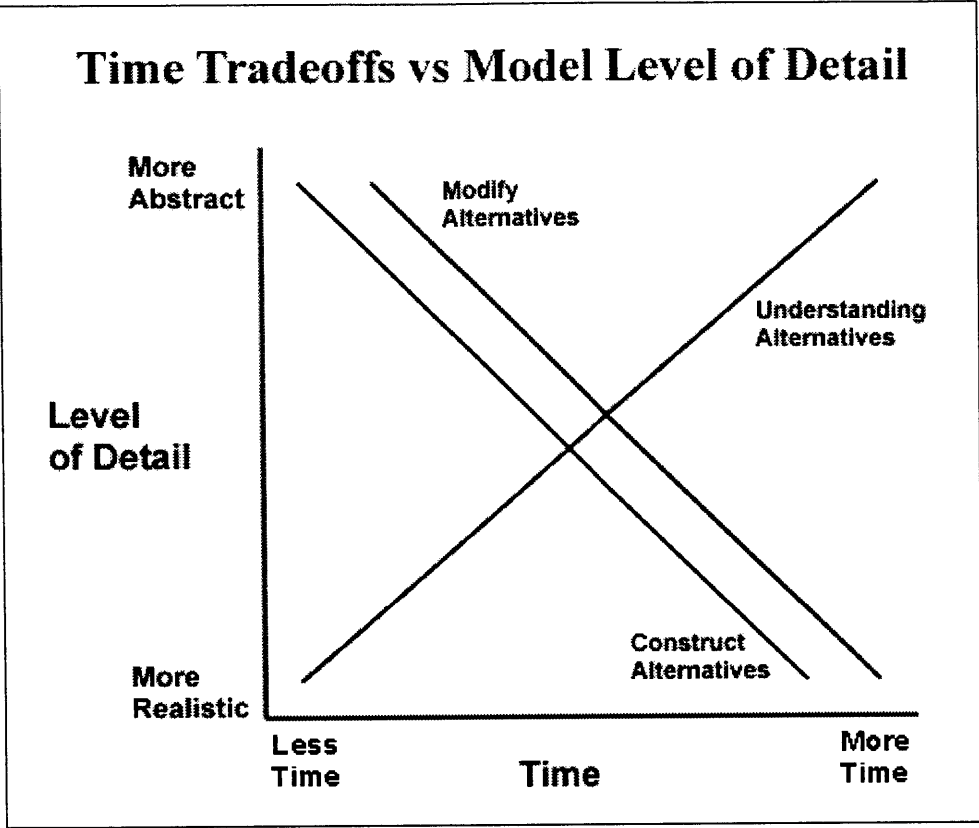
LEGO™ blocks are toys. Many people have played with LEGO™ blocks at some point in their life, and are already familiar with how they work. Thus, the design tool can be expected to be less intimidating than other tools that might not be as familiar. A goal of any design tool is to encourage experimentation. LEGO™ blocks are basic enough to encourage interaction and ‘playing’ out ideas.

A support system that incorporates photo-realistic models has the potential to raise user expectations about what the system should be capable of doing. This can sometimes lead to a negative or frustrating experience with the virtual environment. A LEGO™ model of a portion of the city can still portray the city in a very realistic and recognizable manner. At the same time, the lack of detail can help users focus on the design issues that they are more likely to have control over, such as building heights, density issues, or relative locations. Providing too much detail can easily become a distraction and not a benefit.

LEGO™ bricks allow for rapid scene construction. Creating an urban simulation environment requires much time and detailed work. Building simplified LEGO™ models offer a stepwise approach to better levels of detail. LEGO™-like buildings can be refined and rebuilt over time in order to add detail as study areas change. Memory intensive texture mapping can be limited and rendering performance substantially improved. In some cases, LEGO™ models will provide more geometric detail than photo-realistic texture mapped objects can produce.

LEGO™ models allow for computational performance benefits. Besides decreased texture mapping demands, a LEGO™ model is adaptable to a common graphics technique of changing the level of detail as one's viewpoint approaches an object. The block-like nature of LEGO™ objects allows for easy aggregation of blocks into fewer polygons when a viewer pulls back from a scene. This allows for smoother travel and maximizes the visual effects from different perspectives.

Figure 1 illustrates the tradeoffs between the level of abstraction of a model used to convey a vision for a design and the time it might take residents to create such a model, modify the model, and understand each other's models. A photo-realistic model, for example, conveys almost directly what a design might look like. Residents can immediately identify with the author's vision. However, photo-realistic models take a long time to construct, require more technical savvy, and are difficult to modify. Alternatively, abstract models can be constructed fairly quickly, are easy to modify and update, but usually require more explanation by the author to convey the ideas of the model to others.



**Figure 1: Tradeoffs of Model Level of Detail**

Lastly, LEGO™ blocks are fun! In order to reach the largest audiences, productive virtual environments need to incorporate an element of entertainment. LEGO™ models are fun for people to play with and offer an ideal medium for interacting with spatial and geometric objects such as cities.

**FUTURE LEGO™ BRICKS**

The LEGO™ Group recently released a new product line called LEGO MindStorms™. These are high-tech LEGO™ bricks that can be programmed through a computer serial port connection. Some of the MindStorms™ blocks are equipped with light or touch

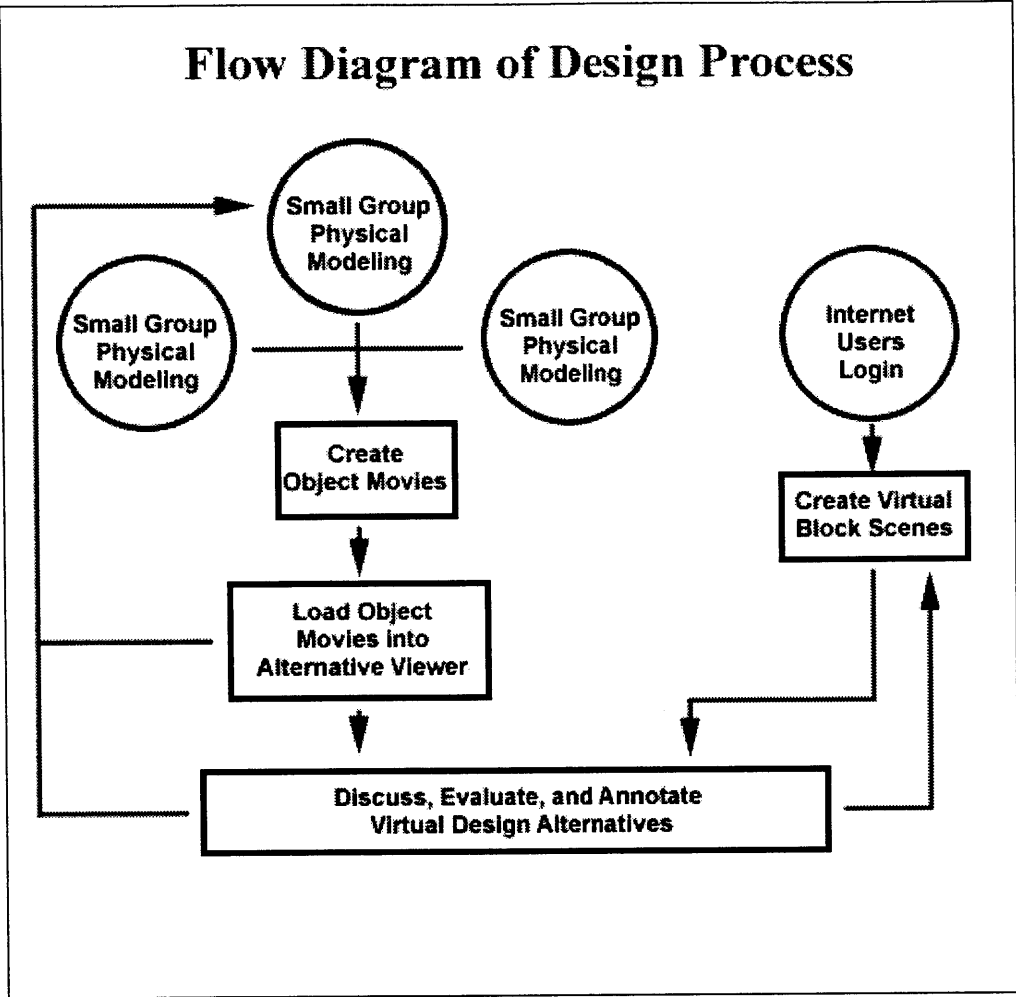
sensors. Research developments such as the Triangles project discussed in the literature review section suggest that one could expect LEGO™ bricks in the near future to have the capabilities for inter-LEGO™ brick communication. Adjacency sensors might be adopted to communicate back to a computer the physical designs created using the tangible medium. Researchers at the Media Lab at MIT have already begun an investigation into the technical aspects of making such a system functional. [Martin, 1994].

Such microprocessor equipped LEGO™ bricks might offer possibilities for interaction similar to Ishii's work with Triangles and the metaDESK. However, in order to keep this research practical and possible for today's neighborhood-based organization, a decision was made to focus on normal, strictly plastic LEGO™ bricks as design tools for part of a larger support system.

## **DESIGN PROCESS MODEL**

### **SMALL GROUP PHYSICAL MODELING**

The participatory visioning exercise incorporates both a physical, or tangible, experience and a virtual, or computer-based, interaction. [Figure 2]. To begin the visioning exercise, residents will form small groups. Each group will have a supply of LEGO™ blocks and baseplates. The planning staff should prepare one or two basic models of the areas for discussion ahead of time, to help the residents visualize the scale of the modeling. Residents will then begin modeling with the blocks, creating basic 3D representations of the current, past, or future design elements.



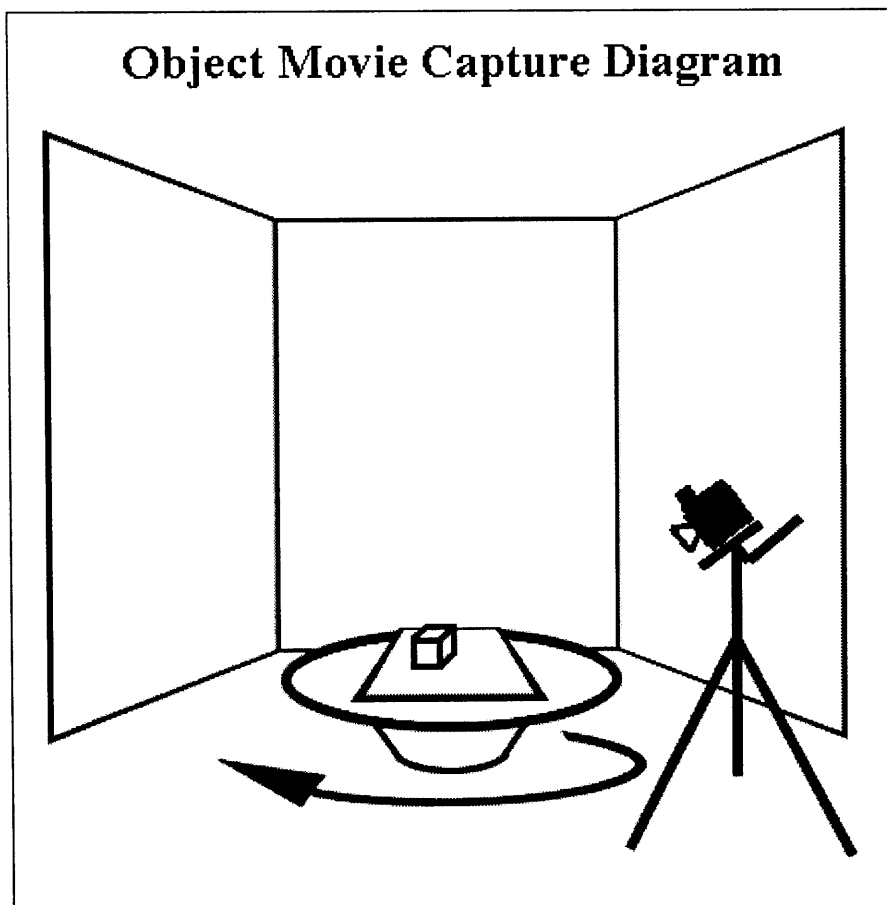
**Figure 2: Flow Diagram of Design Process**

Throughout the modeling process, residents will have the opportunity to ‘save’ their models. Saving one’s model consists of photographing the model with a digital camera, loading the series of images into the Object Movie Authoring Tool software, re-ordering the images as necessary, and saving the model to disk.



## IMAGE CAPTURE

Capturing the images requires some basic setup. [Figure 3]. The digital camera should be mounted on a tripod, with the camera position fixed and pointed at the center of the model. The model should be placed on the center of a turntable, commonly known as a 'lazy-susan'. A cardboard backdrop could be positioned behind the turntable in order to help remove distracting background colors. The cardboard backdrop could be painted a solid color to further minimize background effects. The solid color backdrop could then be replaced at a later time with a video backdrop (using chroma key) to place the model in a realistic context.



**Figure 3: Object Movie Capture Setup**

With everything setup, a series of digital pictures should be collected, taking care to rotate the turntable to a consistent degree incrementally between snapshots.

Approximately 15-20 snapshots should be recorded per object movie. The user may take less snapshots, increasing the incremental angle of turntable rotation. Taking fewer pictures will result in a choppier object movie. However, with fewer source images, the file size of the object movie will be less. A typical object movie constructed from a series of 15 source images recorded at 640 x 480 pixel resolution will have a file size of approximately 500 KB.

Some digital cameras such as the Sony Mavica™ capture images directly to floppy disk. This method is ideal logistically, since each object movie can be recorded on its own disk. Each disk containing the source images should be labeled appropriately, siting the author, date, and possibly a brief description of what had been modeled. Extra care managing the source images is necessary when the digital camera stores pictures on reusable Flash Memory cards. If storing source images for multiple object movies on a single Flash Memory card, one might want to take the extra step of creating individual floppy disks for each object movie series for archival purposes.

## **OBJECT MOVIE AUTHORIZING**

Once a series of images have been recorded, the next step is to create an object movie from the source images. [Figure 4]. The steps for using the software designed as a part of

this research are detailed in the next section. An object movie is an interactive image series that allows a user to rotate an object in real time by ‘clicking’ on that object with the mouse and dragging the cursor. From a programmer’s perspective, the object movie consists of an array of ordered images, with the active display showing one image at a time and swapping that image based on mouse events generated by the user. The object movie is useful for capturing models in that the model can later be viewed from many different perspectives.

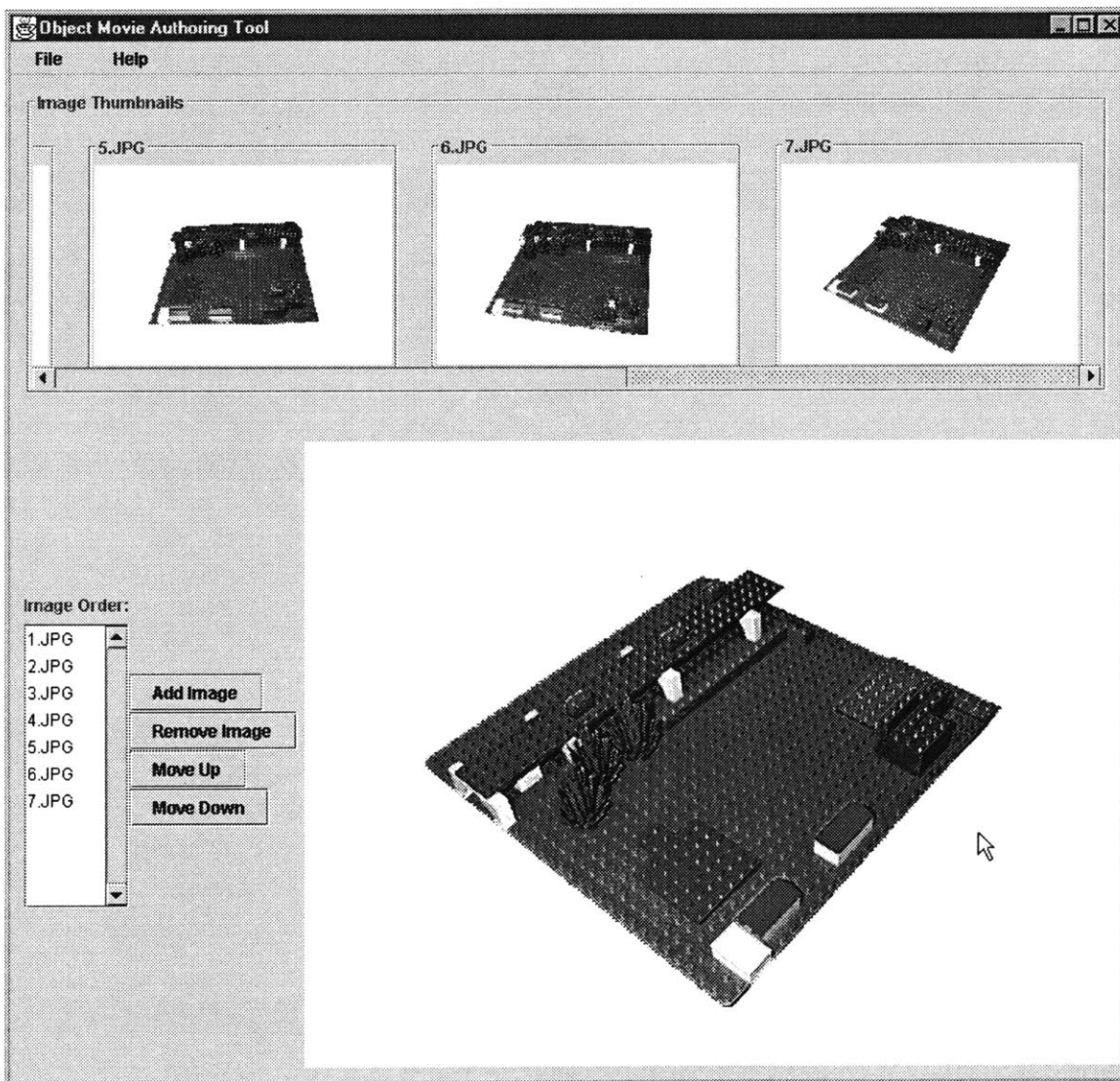


Figure 4: Object Movie Authoring Tool

## **ALTERNATIVE VIEWER**

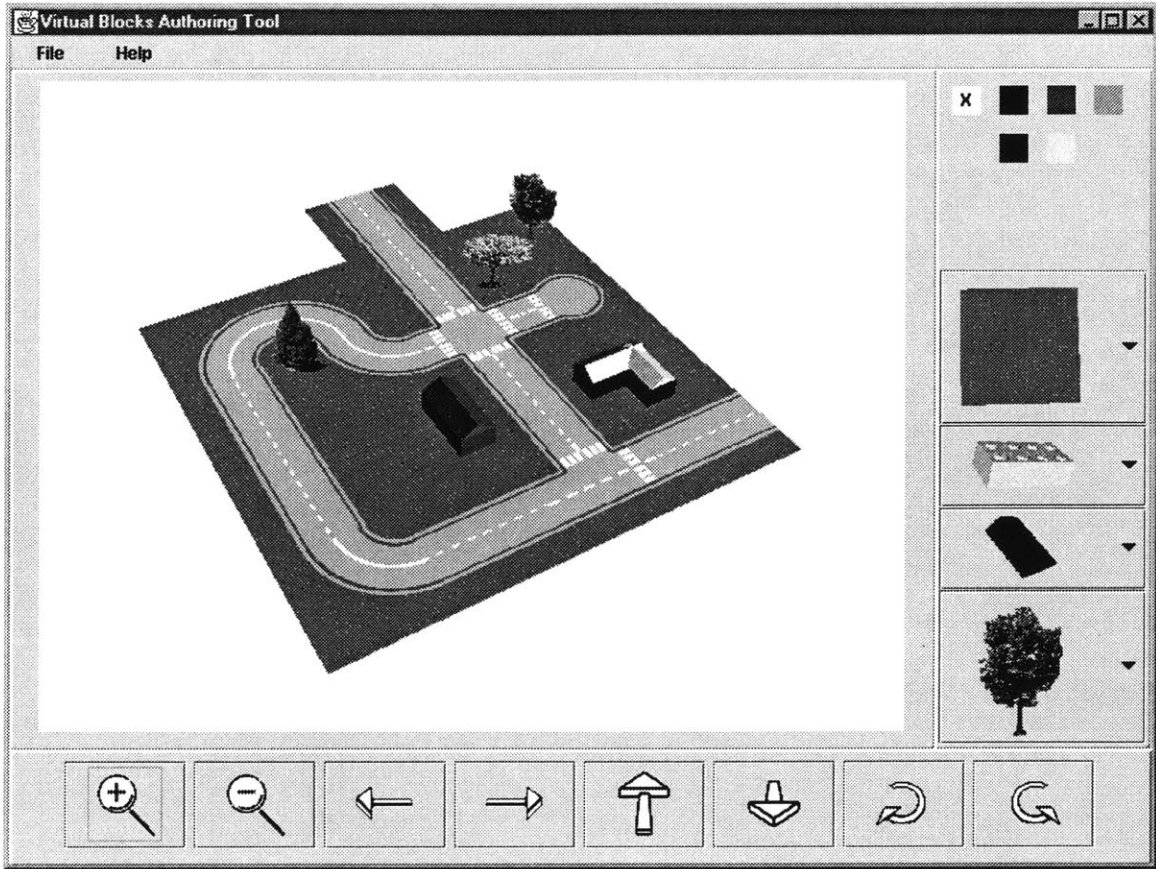
The designing residents should be encouraged to discuss their models with each other and have the opportunity to work on several iterations of their designs, recording object movies for each model constructed. The object movies should be loaded into the Alternative Viewer software. The Alternative Viewer allows residents to see thumbnail overviews of all of the object movies related to a given project. If the neighborhood organization has access to a computer projector, the alternatives can be viewed on a large screen during the meeting as they are created. The Alternative Viewer is designed to be Internet accessible. Residents will have the opportunity to review each of the designed alternatives, adding comments and descriptions to the models via the web interface. More modeling and alternative generation should be encouraged as residents have the opportunity to view each other's designs and reasoning.

The Alternative Viewer initially displays thumbnail size overviews of each of the digital models. Clicking with the mouse on an overview thumbnail launches a viewing window of the model, along with tools for recording comments and descriptions about the model. A running archive of comments for each of the models is automatically saved. The design, annotation, and evaluation process does not have to be completed all in one day. However, an initial description from the author should be recorded as soon as possible. The description might include a brief summary of the problem or issue being addressed, as well as a geographic reference point for the model, such as a nearby street intersection.

The goal of moving the physical model into the virtual realm is to add functionality and value to the model. For example, a virtual representation of a physical model can add value to the process by creating a track record, or archive, of the iterations in designs. The virtual model can be spun around similar to manipulating the model physically. Additionally, including textual descriptions and annotations can augment the virtual model. Finally, a virtual representation can augment users' understanding of a model by allowing users to visualize the model from multiple perspectives, including those that simulate a viewpoint as if one were standing within the model itself.

#### **VIRTUAL BLOCK AUTHORIZING TOOL**

A Virtual Block Authoring Tool allows residents to design alternatives online. [Figure 5]. Users of this tool are still encouraged to first think out their designs using real, tangible LEGO™ blocks. Working with the tangible medium allows for deeper interaction with the model, and generally will be a faster process. Using the Virtual Block Authoring Tool, the remote user can replicate her tangible model by rebuilding it virtually. The scenes created using the Virtual Block Authoring Tool can be saved and recalled at later times, allowing any user to expand on or incorporate others' designs. This feature encourages collaborative work, conducive to participatory planning.



**Figure 5: Virtual Block Authoring Tool**

The next sections describe in greater detail the design and use of each of the software components: the Object Movie Authoring Tool, the Virtual Block Authoring Tool, and the Alternative Viewer. The source code for the overall planning support system is included on the CD-ROM.

## **GENERAL SOFTWARE DEVELOPMENT DECISIONS AND RATIONALE**

### **SURVEY OF GRAPHICS APIS**

A number of different decisions had to be made over the course of developing the software. Initial research was devoted to a review of various computer graphics development environments, including OpenGL, DirectX, VRML, Java3D, GLIDE, and Fahrenheit. Table 1 describes the pluses and minuses of each. For this planning support system, some major issues included portability across platforms, ability to run via the Internet, scalability, and ease of development given a short development time. VRML (Virtual Reality Markup Language) and Java3D were both the easiest to learn, and best suited for deploying via the Internet.

Java3D, a high level API, was selected as the graphics API of choice for this software for several reasons. First, since Java3D is a high level API, layered on top of lower level APIs such as OpenGL and DirectX, Java3D allows the developer to concentrate on developing 3D content rather than spending time worrying about the low level rendering details. Java3D inherits many of the positives of OpenGL and DirectX, since both are really a part of Java3D. Another major benefit of the Java3D API for this software prototype is the ability to integrate the power of other Java APIs seamlessly, creating a complete, integrated suite of tools. As a high level API, Java3D should be adaptable to new improvements in low level graphics APIs, such as the upcoming Fahrenheit API.

Along the same lines, file loaders have been developed for importing most major 3D graphics file formats, including VRML files, into Java3D. Thus, future improvements to this software will be able to incorporate the power of other graphics authoring packages.

All software was coded using Sun Microsystems's Java Software Development Kit (SDK) version 2.0.1. In addition to the SDK 2.0.1, Sun's Java3D Standard Extension Application Programming Interface (API) version 1.1.1 was used within both the Alternative Viewer and the Virtual Blocks Authoring Tool.

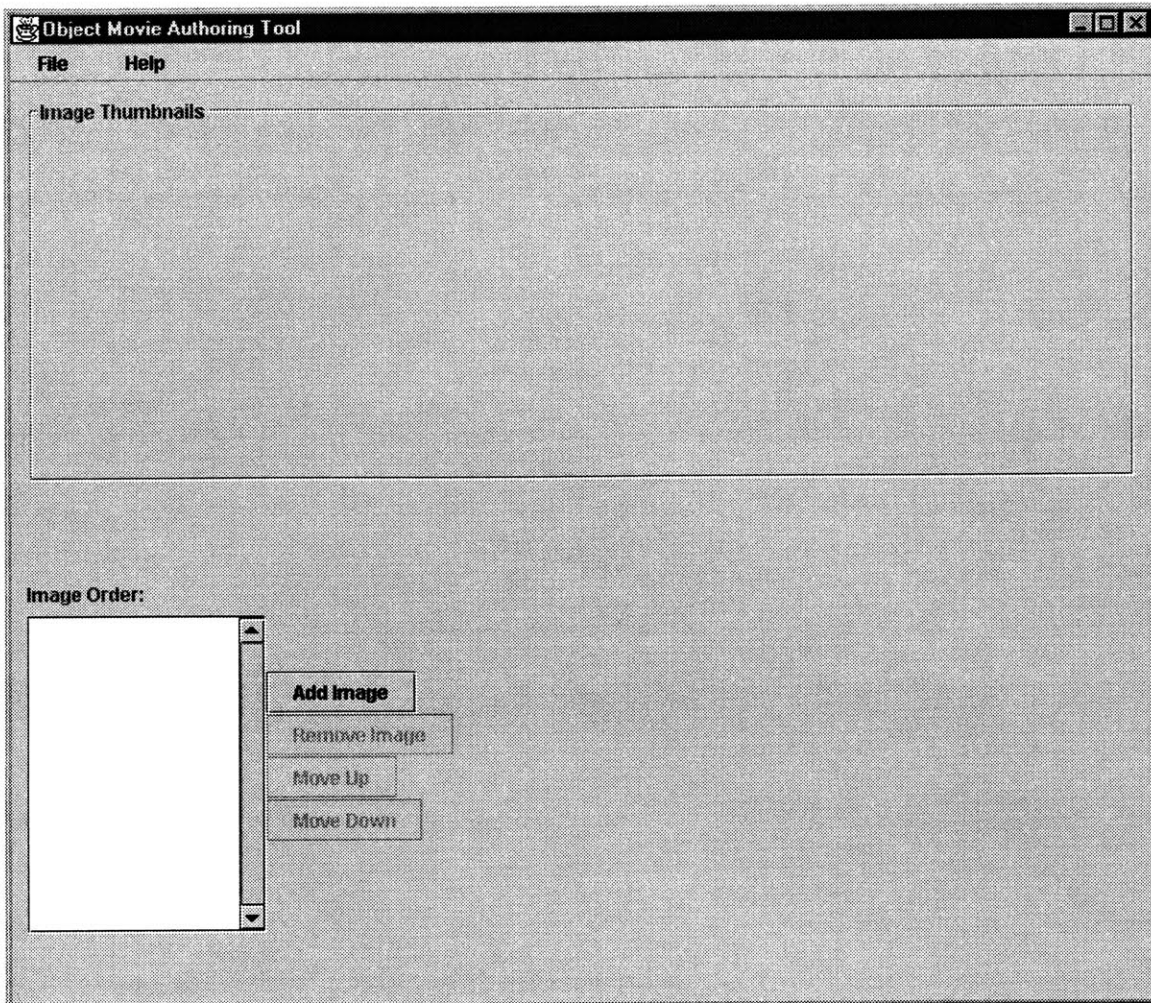


**Table 1: Summary of Graphics APIs**

<b>Graphics API</b>	<b>Developing Corporation(s)</b>	<b>Pluses</b>	<b>Minuses</b>	<b>Website</b>
OpenGL	SGI (formerly Silicon Graphics)	The Industry Standard Graphics API; Very well documented; Platform portability	For this project, a minus that it is a Low Level API, since all aspects of rendering the scene graph need to explicitly be defined; By itself, not web ready.	<a href="http://www.opengl.org">www.opengl.org</a>
DirectX	Microsoft Corporation	Extremely Fast on Windows 9x; Sound, 3D, and haptic force-feedback capabilities; Most games for Windows use this development environment	Most recent versions only usable on Windows 9x, and not NT (this will change as of Windows 2000);	<a href="http://www.microsoft.com/directx">www.microsoft.com/directx</a>
VRML	Defined through the International Standards Committee (ISO) for computer graphics and image processing	Most widely used web-based virtual reality development language; Easiest syntax to learn;	Limitations on real time scene development (requires aid of Java-EAI, which is buggy); A file format, not a programming language	<a href="http://www.vrml.org">www.vrml.org</a>
Java3D	Sun Microsystems	High Level Language; A Programming Language, not a file format; Integration with other Java APIs; Portable; Scaleable; Layered ontop of OpenGL or DirectX; File Loaders for every major 3D Graphics Authoring Tool (ie. '.obj', '.dxf', etc.)	Recent release, relatively little documentation; Requires Java Plugin and some additional setup for deploying over Internet (because of it's newness); Slower performance since Higher Level Language	<a href="http://sun.com/desktop/ava3d/">sun.com/desktop/ava3d/</a>
GLIDE	3dfx	Fast graphics in combination with Voodoo chipset (only works with this Hardware)	Low Level API, specific to 3dfx Voodoo chipset	<a href="http://www.3dfx.com">www.3dfx.com</a>
Fahrenheit	SGI (formerly Silicon Graphics) and Microsoft Corporation	Will replace OpenGL and DirectX; Includes Large Model VisualizationAPI, Scene Graph API, and Low Level API	Not yet released; Will be introduced in stages, completed in year 2000	<a href="http://www.sgi.com/fahrenheit/home.html">www.sgi.com/fahrenheit/home.html</a>

## **OBJECT MOVIE AUTHORIZING TOOL**

The Object Movie Authoring Tool is designed to be simple and straightforward in both interface and functionality. [Figure 6] The basic layout of the user interface includes a top panel for viewing the thumbnails of the individual source images making up the object movie. A side panel containing a series of four buttons, labeled 'Add Image' for adding an image, 'Remove Image' for removing an image, 'Move Up' for moving the selected image up in the order of images, and 'Move Down' for moving the selected image down in the order of images. A scrollable list box is placed next to the buttons, listing the names of all of the image files currently loaded into the application. And a panel is included for the object movie to be displayed dynamically.



**Figure 6 : Initial Startup Layout, only the Add Image button is enabled.**

Images are loaded into the application by clicking the 'Add Image' button or by selecting 'Open...' from the 'File' menu. [Figure 7]. A file chooser dialog box prompts the user to select the source images. A file filter programmed into the file chooser dialog box displays only those files with a '.gif' or '.jpg' file extension. Only GIF or JPEG source images may be loaded into the application.

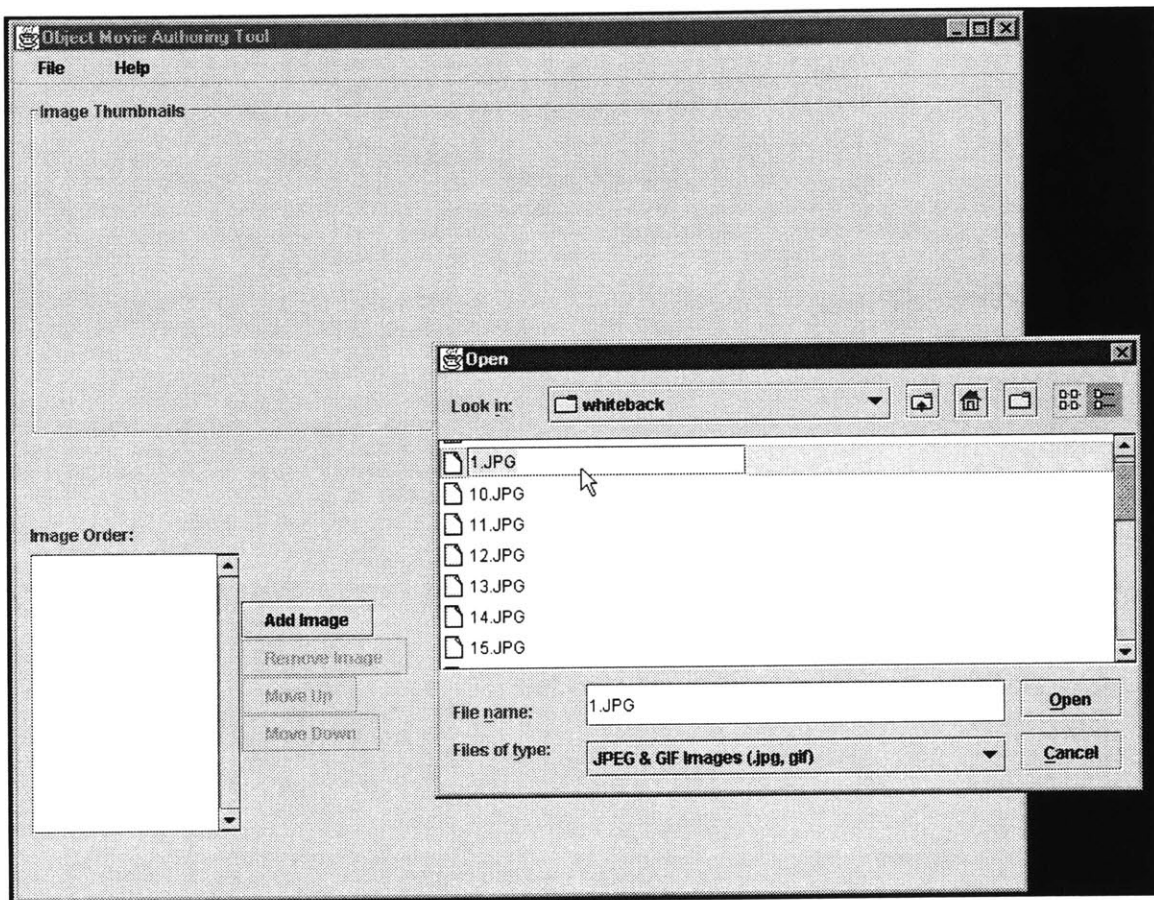
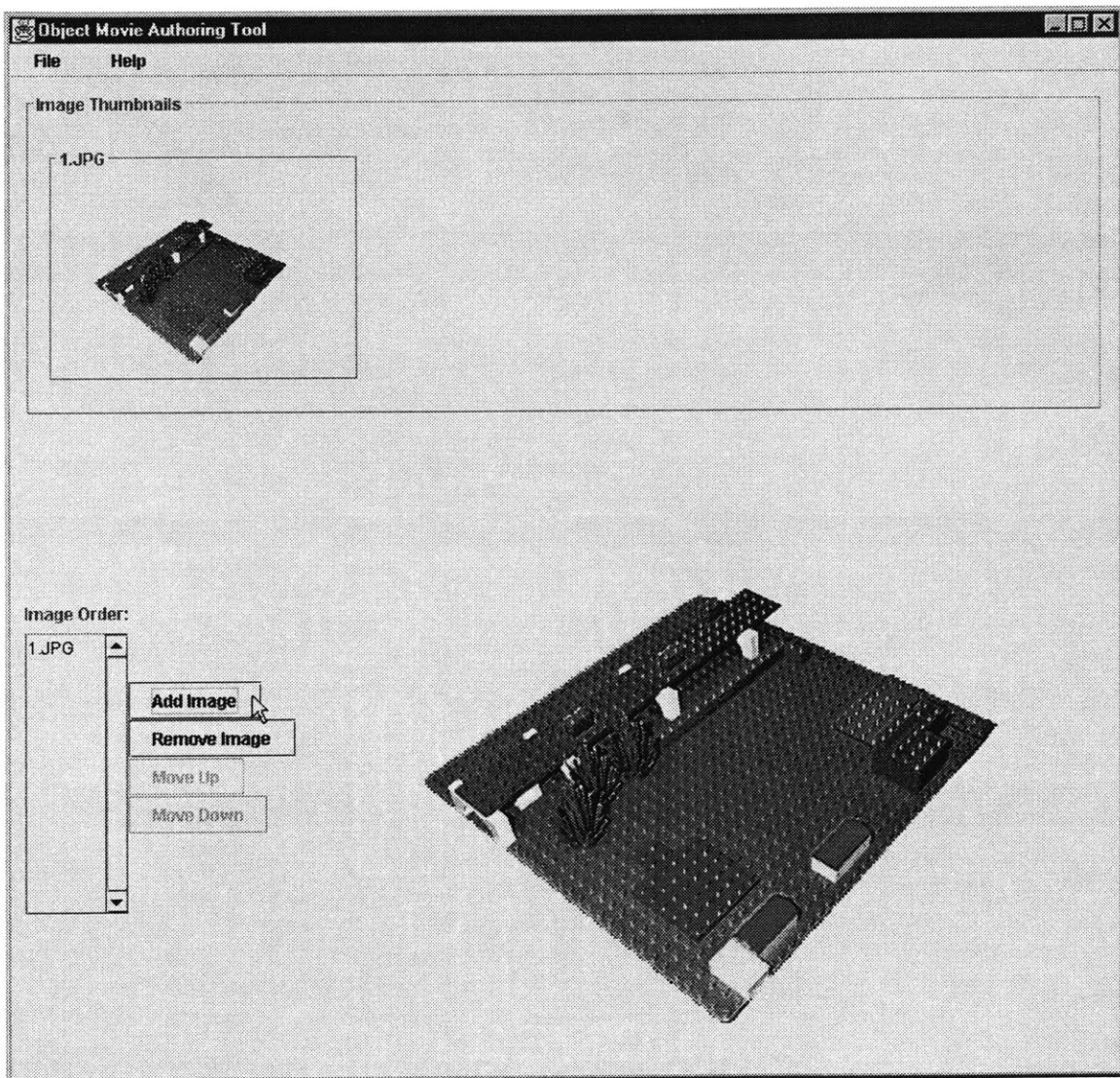


Figure 7: Adding images, File Chooser Dialog

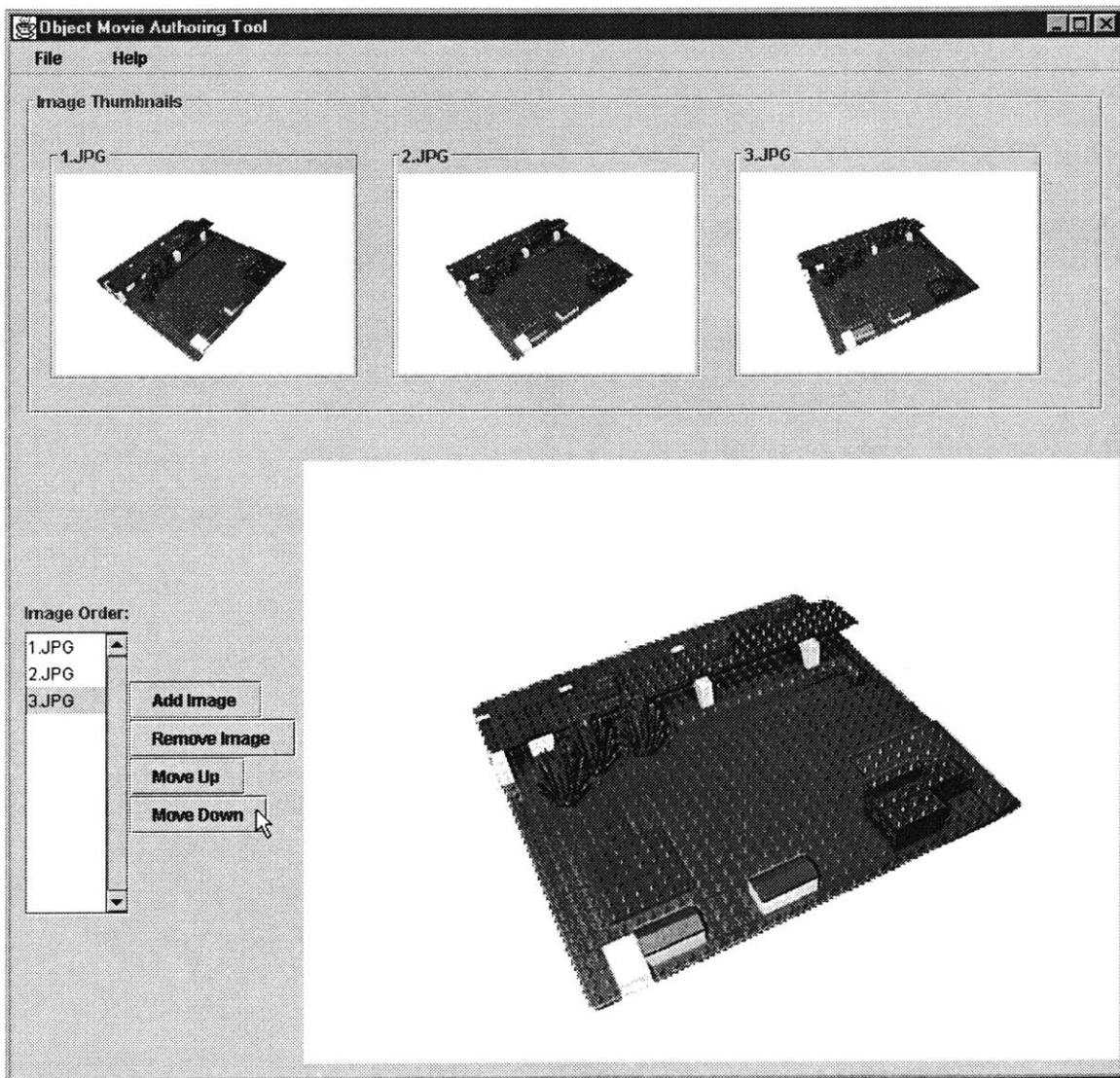
Adding an image changes the layout in several ways. [Figure 8]. First, a thumbnail of the image, along with the name of the image, is added to the 'Image Thumbnails' panel. The name of the image is also added to the selection list box next to the buttons. As long as one or more images are loaded into the application, the 'Remove Image' button will be enabled.



**Figure 8: First image from series added.**



Selecting an image from the list box and pressing the 'Remove Image' button removes the image from the series. Every time an image is loaded, the object movie is dynamically created and displayed. Clicking and dragging the mouse on the object movie spins the model through the series. If certain images appear out of order when the object movie is rotated, the 'Move Up' and 'Move Down' buttons can be used to re-order the series. [Figure 9].



**Figure 9: Reordering Image Sequence**

As more images from the series are imported, the object movie begins to take shape. The 'Image Thumbnails' panel becomes scrollable as soon as the total number of images fills the width of the display. [Figure 10].

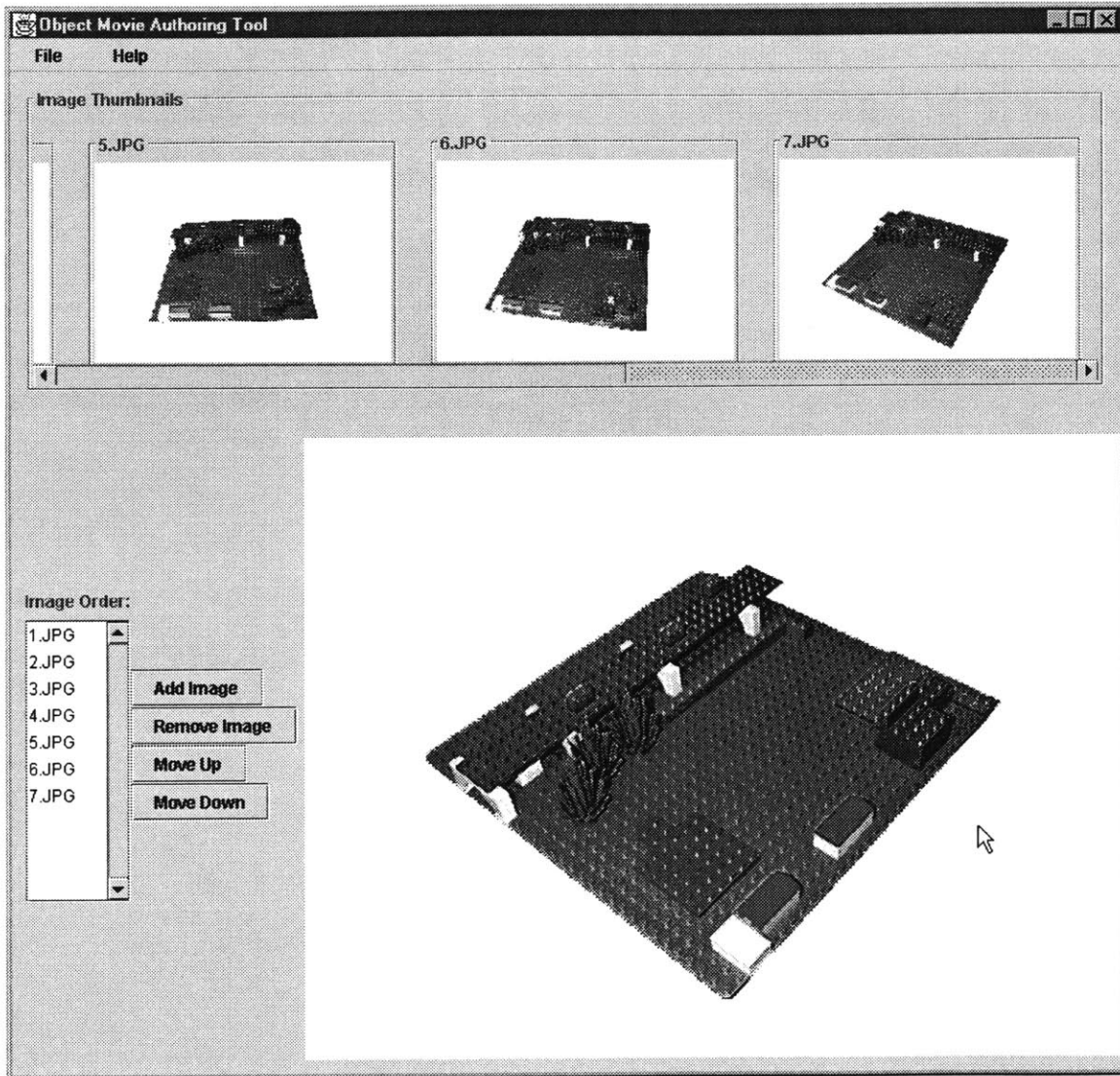


Figure 10: Scrollable Image Thumbnails

In addition to being able to dynamically spin the object movie as it is created, the user can zoom into the model using the 'up arrow' key and can zoom out using the 'down arrow' key on the keyboard. [Figure 11]. The model stays fixed at the current zoom level even when spinning the model. The image is resampled on the fly by the software, such that multiple resolutions of the image need not be stored ahead of time.

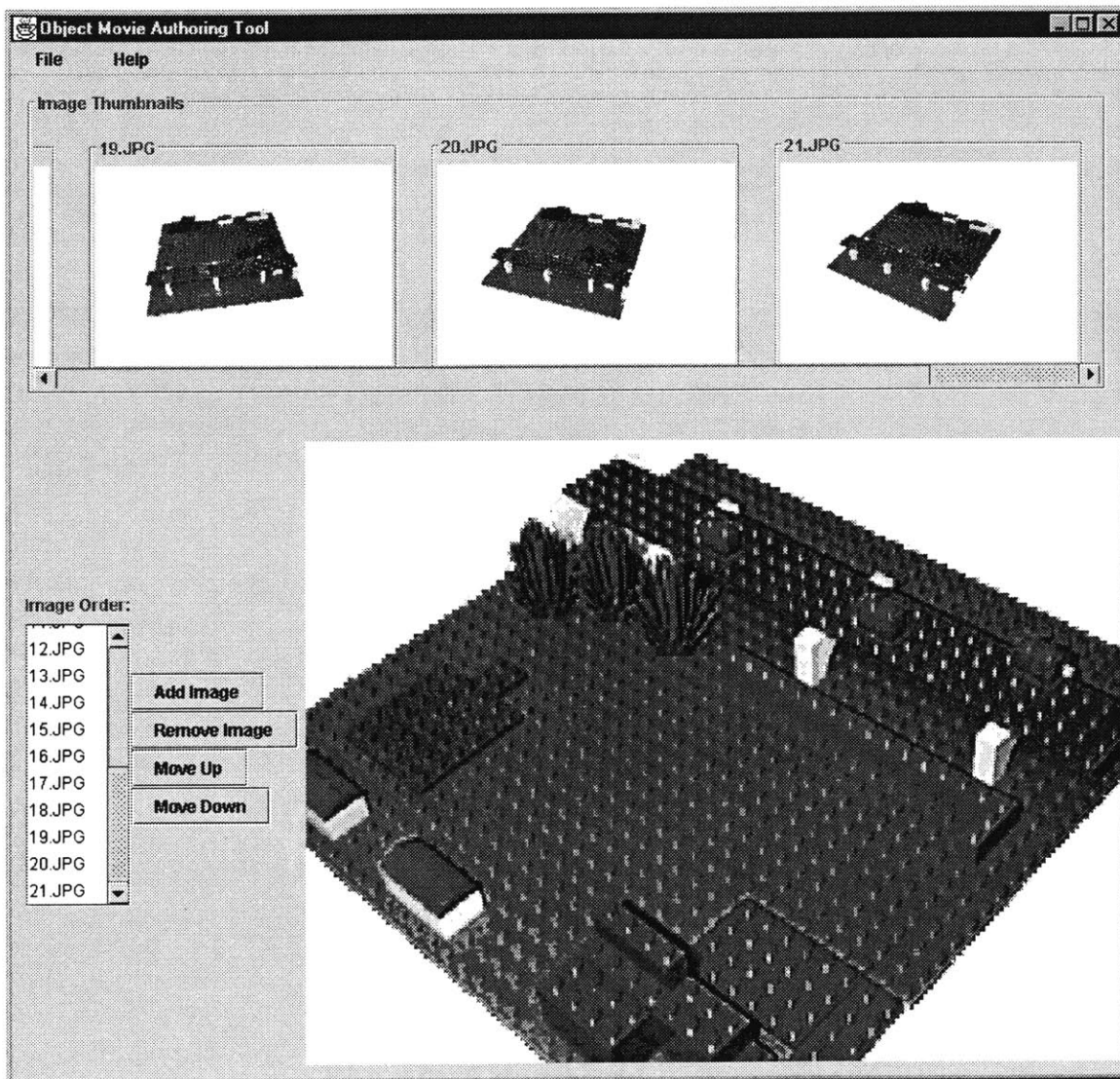


Figure 11: Zoom Capabilities



After loading each of the source images and verifying the proper sequence of frames by spinning the object movie, the user is ready to save the object movie. Selecting 'Save As...' from the 'File' menu opens a 'Save File As...' dialog box, prompting the user to name the file. The file is given a '.jar' file extension. A JAR file is a compressed, Java-ARchive file that is similar to a ZIP file. Packaged in the JAR file is the properly ordered image series that makes up the object movie. All the files compressed inside the JAR file are JPEG encoded, whether the source images originally were GIF or JPEG images. The JAR file should then be placed onto the web server, with the other object movies. If the source images are ever lost or damaged, the individual images can be uncompressed from the corresponding JAR file using a tool such as WinZip<sup>5</sup>.

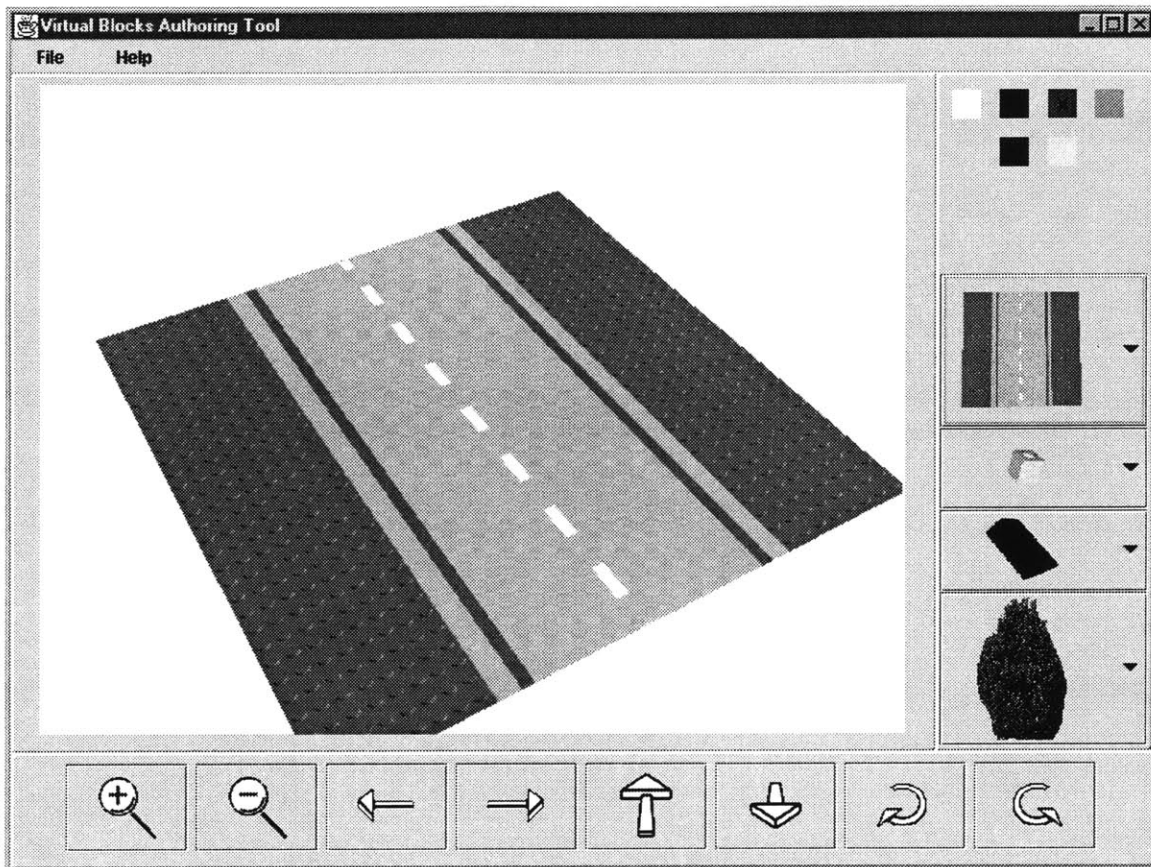
### **VIRTUAL BLOCKS AUTHORING TOOL**

The Virtual Blocks Authoring Tool allows the user to create scenes similar to object movies, only instead of importing a series of images, the user constructs the scene within a 3D virtual reality graphics space. The layout of the Virtual Blocks Authoring Tool consists of a canvas for the display of the 3D graphics rendered in real time. The canvas initially is blank. The user can open up a saved scene and expand on its design, or start a new design by selecting objects to add into the scene from the pull down menus. [Figure 12].

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<sup>5</sup> WinZip is a software tool distributed by Nico Mak Computing, Inc. <http://www.winzip.com>

Several different baseplate designs exist to help the user rapidly model the terrain and street network of their neighborhood. Some of these plates include solid green plates, straight road plates, curved road plates, intersection plates, and culdesac plates. Each baseplate consists of a box 32 x 32 units in size with an

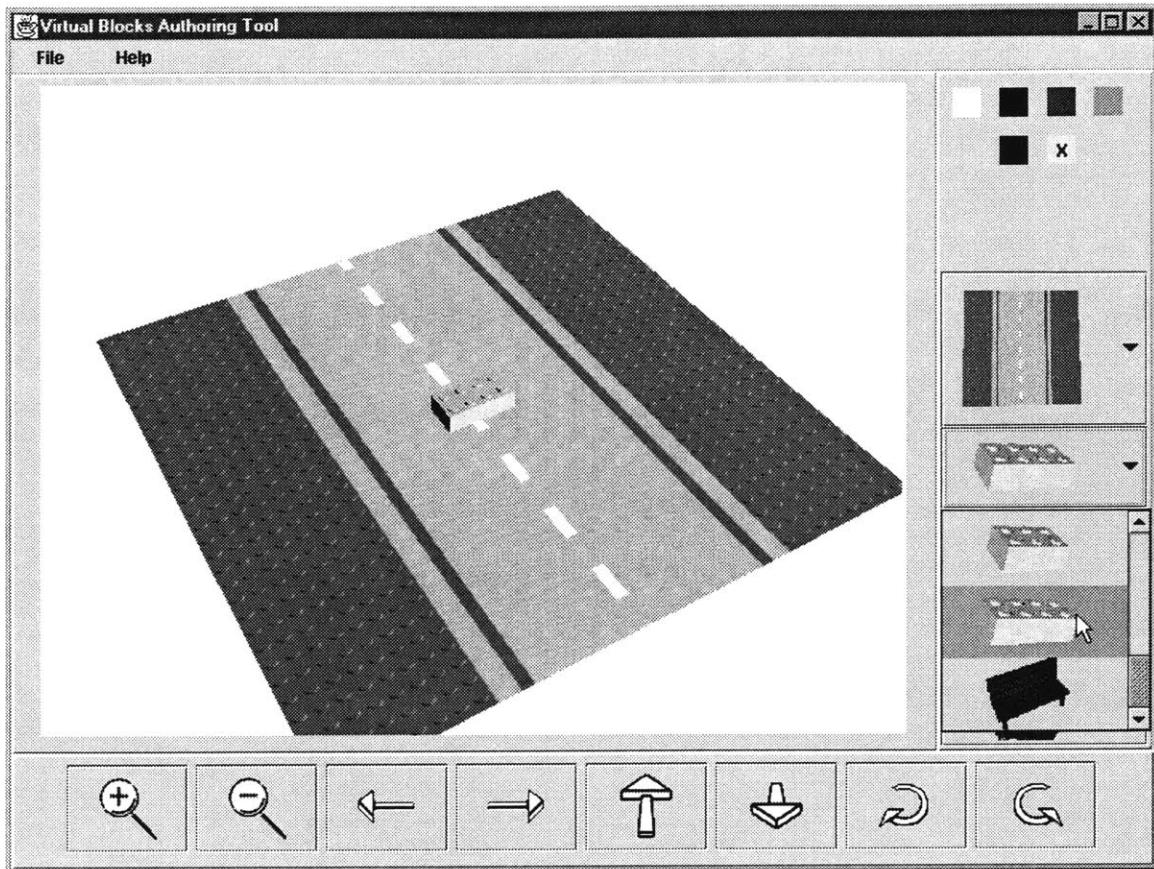


**Figure 12: A Virtual Baseplate To Build On.**

image texture-mapped to its face. The textures were generated with Adobe Photoshop™ software. Texture mapping the baseplates as opposed to generating the geometry for each dimple (cylinder) on the plate provides significant performance gains. For example, a solid green baseplate, 32 x 32 units in size, would require 1024 cylinder geometry objects to construct just the dimples. While methods exist to share the geometry data of

the cylinder, the system performance slows compared to using a texture map. The textured image could be any image, including orthophotos, or custom street network layouts.

In addition to a library of virtual baseplates, other menus include libraries of various sized blocks, pre-modeled objects such as a park bench, and texture-mapped objects such as photo-realistic trees, lampposts and people. Selecting an object from the iconic pull down menus automatically adds the object into the virtual scene. [Figure 13]. Above the menus is a radio button set of colors, allowing the user to select the color of the next block to be added to the scene. The user may set the color to black, white, red, green, blue, or yellow.



**Figure 13 : Adding Objects to the Scene**

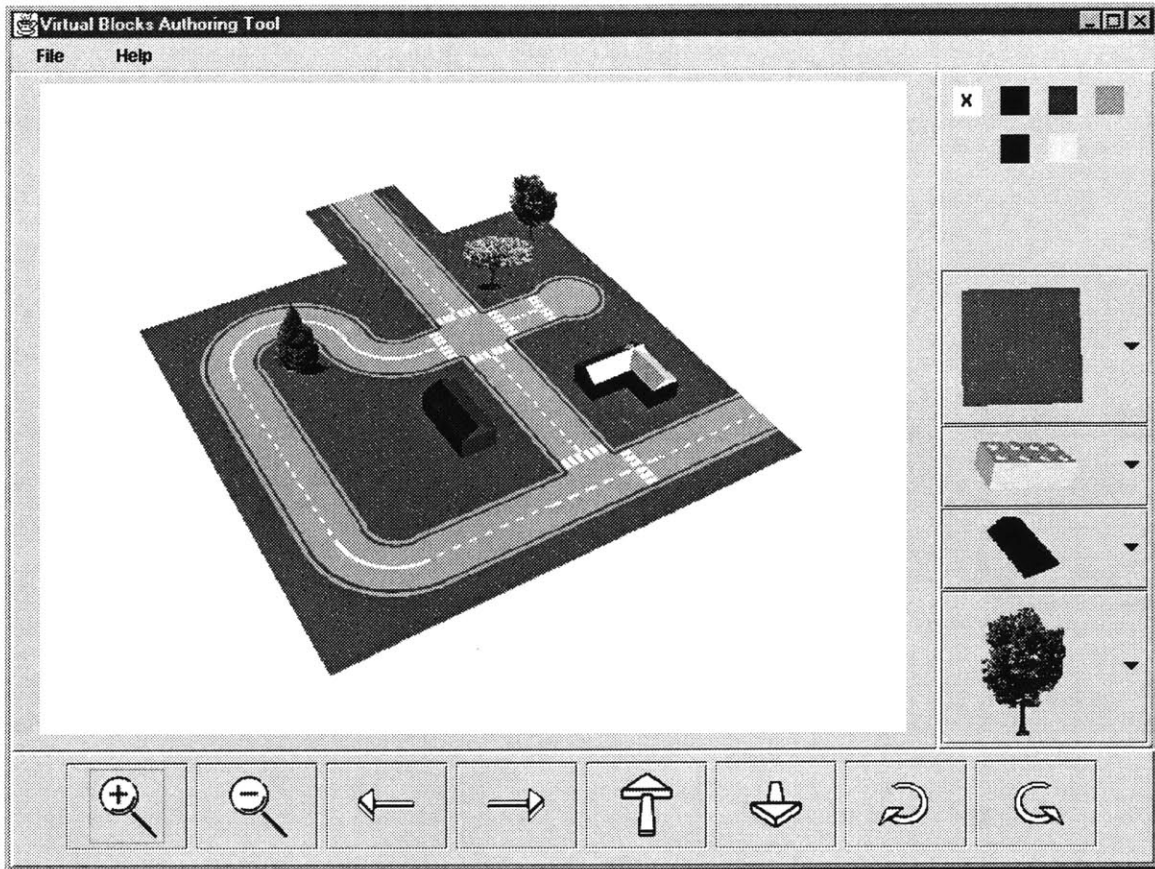
Below the 3D canvas are controls for changing the viewpoint and for navigation. The user can zoom in and out, and pan around the model. The navigation controls simulate travel within the virtual universe and offer infinite perspectives on the model. By making adjustments to the perspective on the virtual model, a user can simulate a feeling of actually standing inside the model. These street level visualizations and navigation controls help bring the design concepts encapsulated in the virtual model closer to reality and allow for better communication and interpretation of a particular design.

### *Controlling Block Placement in 3 Space*

Each object added to the scene will be 'pickable'. Selecting an object consists of clicking on that object with the mouse. By picking an object, the software recognizes that this is the object the user wishes to translate or rotate. The keypad controls object translation. Pressing the up arrow on the keypad moves the object one unit in the negative z direction. Similarly, the down arrow controls movement in the positive z direction, the right arrow provides translation in the positive x direction, and the left arrow increments the block in the negative x direction. The blocks vertical position will be controlled with the 'Page Up' and 'Page Down' keys. Lastly, rotation of the object (90-degree increments) will take place upon pressing the 'r' key for rotate. Anytime a new object is added to the scene, that object will automatically be 'picked'. Thus, using the arrow keys, the Page Up/Down keys, and the 'r' key, the user can quickly position the object within the virtual scene.

### *Saving Scenes*

Once the desired scene is created, the scene may be saved. The virtual scenes require a custom file format extension in order for the Alternative Viewer to be able to read the saved scene. The extension to use is '.vcp', for a Virtual City Plan file. VCP files can be opened and modified after being saved. Thus, expanding on design alternatives is possible. Pictured below is a saved scene that was created in just five minutes using the Virtual Blocks Authoring Tool. [Figure 14].



**Figure 14: An Example of a Saved Scene**

## **ALTERNATIVE VIEWER**

The Alternative Viewer allows the residents to share their models and collaboratively discuss and develop alternatives. The Alternative Viewer is a web-based applet that can be viewed within a web browser such as Netscape™ or Internet Explorer™. The Viewer displays thumbnail images of the various submitted designs. The thumbnails reference either object movies or 3D virtual designs, depending on the authoring tool used to create

the media. Selecting a thumbnail pops up a new window, with the appropriate viewer and control panel. Each scene viewer reuses the viewing control systems used in the authoring packages. Each viewer also contains a text box for typing in comments and annotations about the scene. A record of all annotations is kept for each submitted design, and can be viewed by scrolling through the comment history.



## A HYPOTHETICAL EXAMPLE TO ILLUSTRATE THE SYSTEM'S USE

Planning for the redevelopment or reuse of open space in a community is particularly well suited for this research. Open spaces offer an ideal 'template' for constructing alternative visions for development. In order to demonstrate how these software tools might be used within a public participatory visioning context, several fictional alternatives were generated for an underdeveloped parcel of land located in Roxbury, Massachusetts.

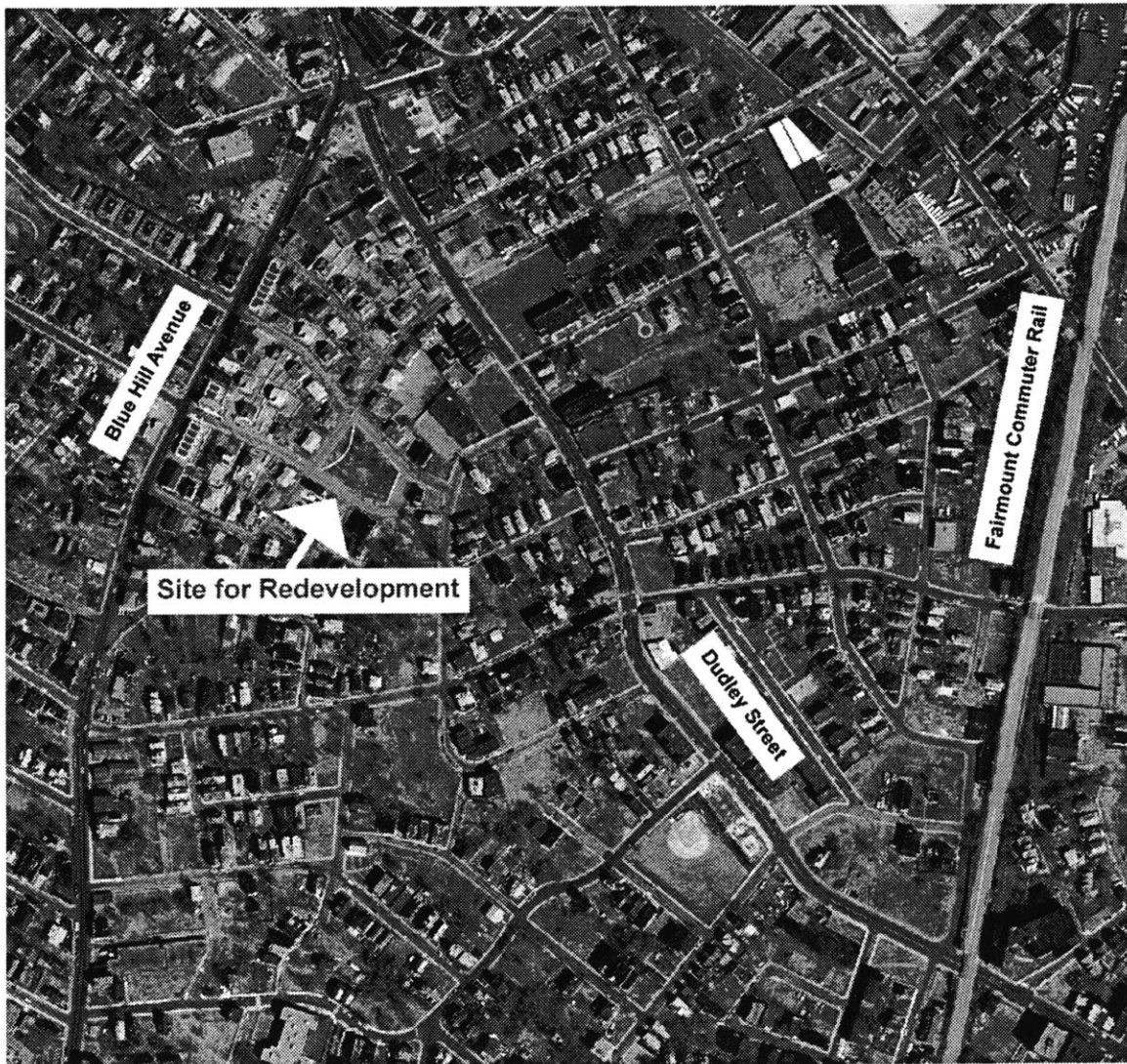


Figure 15: Example Site for Redevelopment





**Figure 16: Currently an Open Space Land Use**



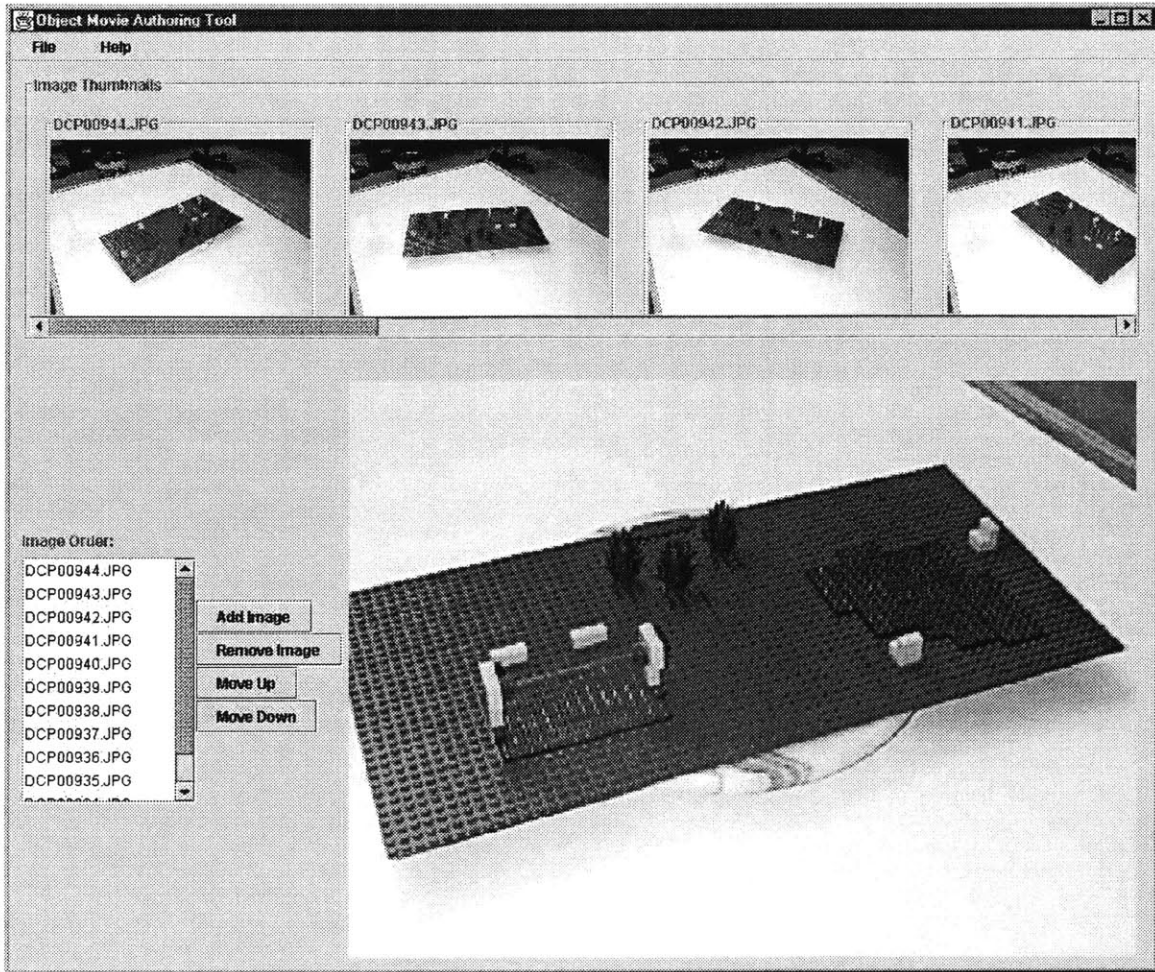
**Figure 17: Overgrown Weeds and Dying Grass**

This type of underutilized land is common ground in neighborhoods that have had difficulty attracting economic development and investment.

## **EXAMPLE ALTERNATIVES**

### *Visualization of Basketball Court and Pond for Fishing*

Several alternative uses might be of interest to neighborhood residents. For example, the neighborhood might want to invest in better maintenance of the park, while retaining its open space land use. A group of residents interested in improving the recreational use of the park might work out several of their ideas using physical LEGO™ bricks. Using the physical LEGO™ bricks, issues of placement of features within the site, such as where to locate a basketball court, might be experimented with. As the group ‘plays’ out several ideas, they may want to archive their designs digitally. After taking a series of digital photos of the model, the Object Movie Authoring Tool can be used to assemble a virtual representation of the physical model. Figure 18 illustrates a fictitious model of a basketball court, some trees, benches, and a lake as an alternative for the site.

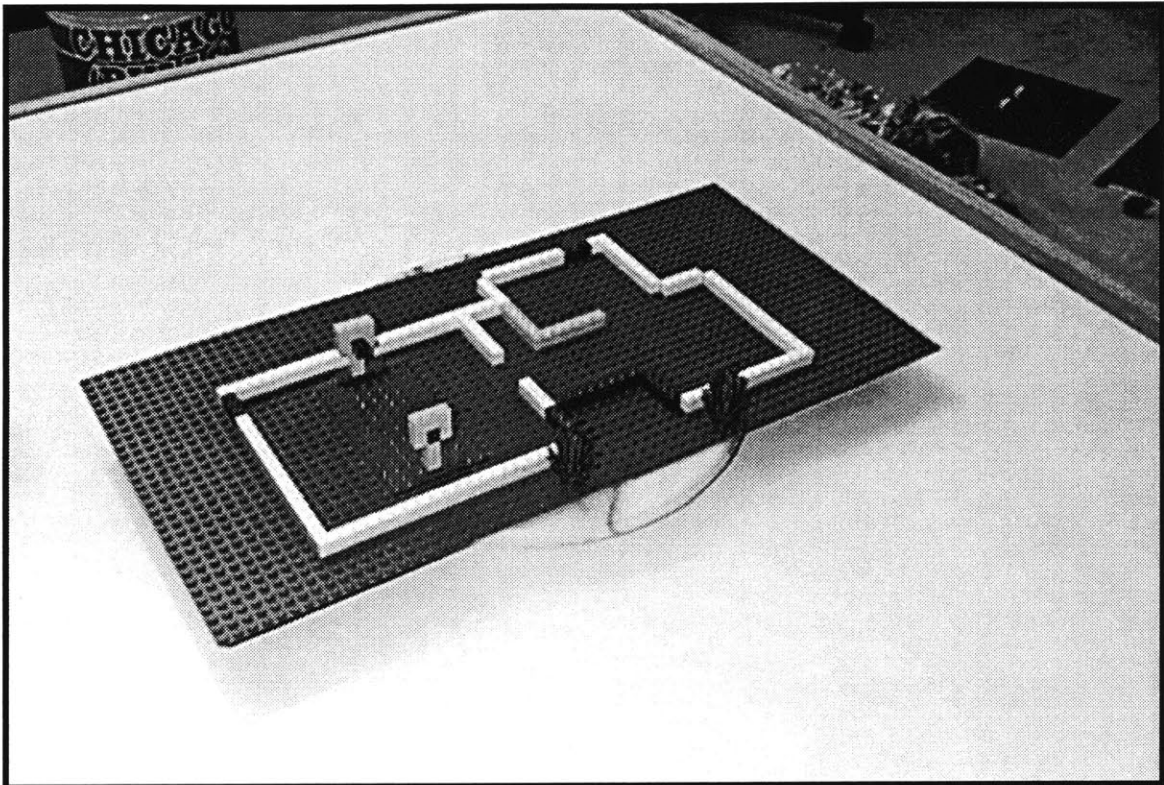


**Figure 18: An Object Movie of a Physical LEGO™ Model**

### *Visualization of a Community Center*

As physical models are constructed and archived as object movies, other meeting participants will have the opportunity to visualize each other's designs. For example, seeing a visual representation of the design for a park with a basketball court and a lake might spawn discussion about the importance of developing this land for year-round use. Some might point out that a lake could be used for fishing in the summer, and for ice

skating in the winter. Others might suggest an alternative for making the basketball court option a year-round use by enclosing the court within a community center building. A LEGO™ model of the floor plan for a potential community center might be constructed as an alternative. [Figure 19].



**Figure 19: Community Center Floor Plan**

The object movies allow the model to be archived and revisited after the model has been deconstructed. The object movie allows participants to visualize the model from each of the viewpoints captured with the digital camera. This is useful for visualizing models because elements within the model can occlude other elements behind them. A single still picture thus would not capture all of the features that might be included in the design.

If the building modeled were an enclosed structure, the user might want to create multiple object movies of the model, making sure that one of the movies was open to visualizing the detail within the closed structure.

While the object movie media is useful for archiving physical models, it can be limited in visualization options. For example, the user can only rotate the model and zoom in and out. Participants might want to visualize the model as if they were actually standing inside the model. Another limitation with the object movie media is that the objects in the object movie cannot be modified easily. Thus, in order to build off of an archived design, a participant would have to physically reconstruct the model, and then make their adjustments. Lastly, the object movie authoring process is not well suited for those wanting to participate remotely, or at a later time, via the Internet since each participant would need her own digital camera for recording the physical models.

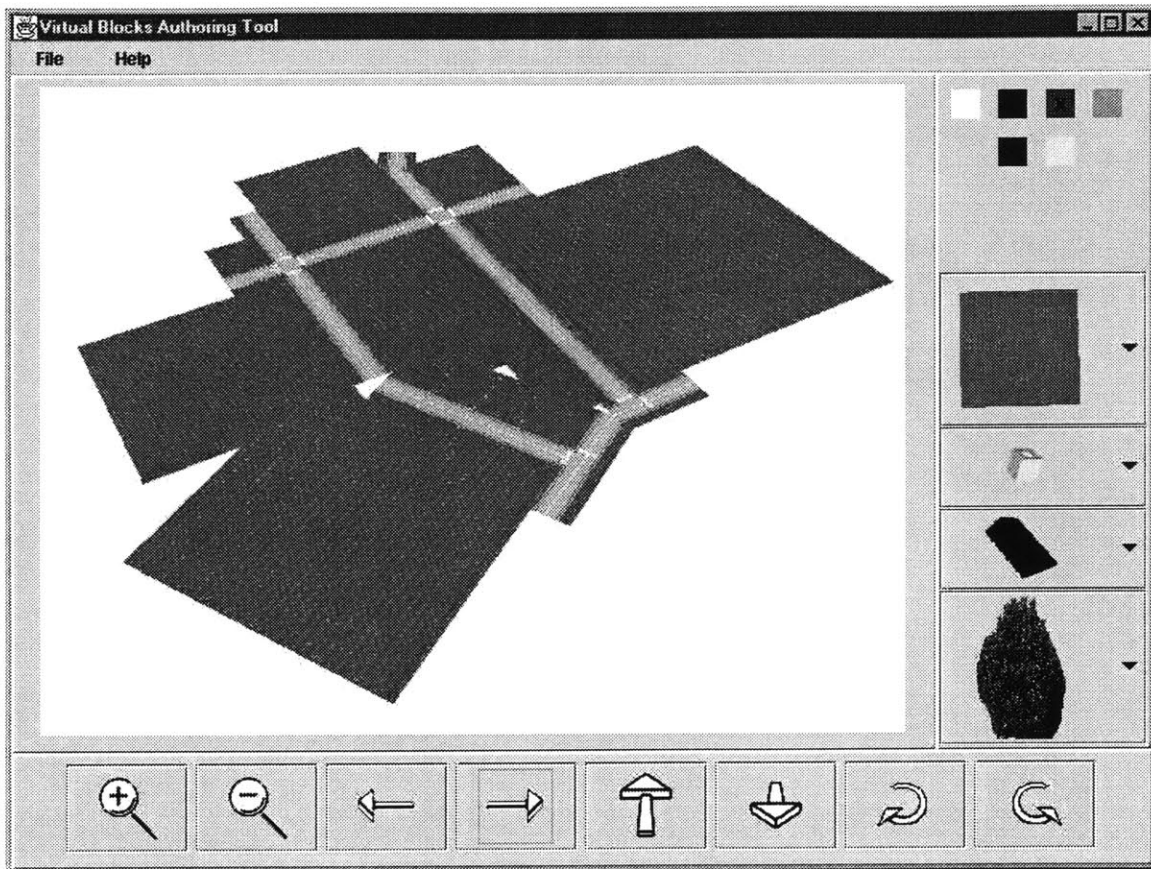
### *A Virtual Template*

The Virtual Blocks Authoring Tool helps overcome some of the limitations of the object movie media. The Virtual Blocks Authoring Tool allows people to participate in the construction of design alternatives when they are not able to attend the meeting in person. Since the tool includes a virtual library of LEGO™ bricks, the remote users do not even have to have the physical blocks at hand. However, in situations where remote participants do have LEGO™ blocks, it might be easiest for them to first construct and work out their design ideas using the physical blocks, and then input their completed design alternatives into a digital archive using the Virtual Blocks Authoring Tool. The

interaction with the physical blocks is both faster and more intuitive than using a mouse and keyboard to control the placement of blocks within a virtual model.

The sponsoring neighborhood organization might use the Virtual Blocks Authoring Tool to create a site-specific template for remote users to incorporate their designs into.

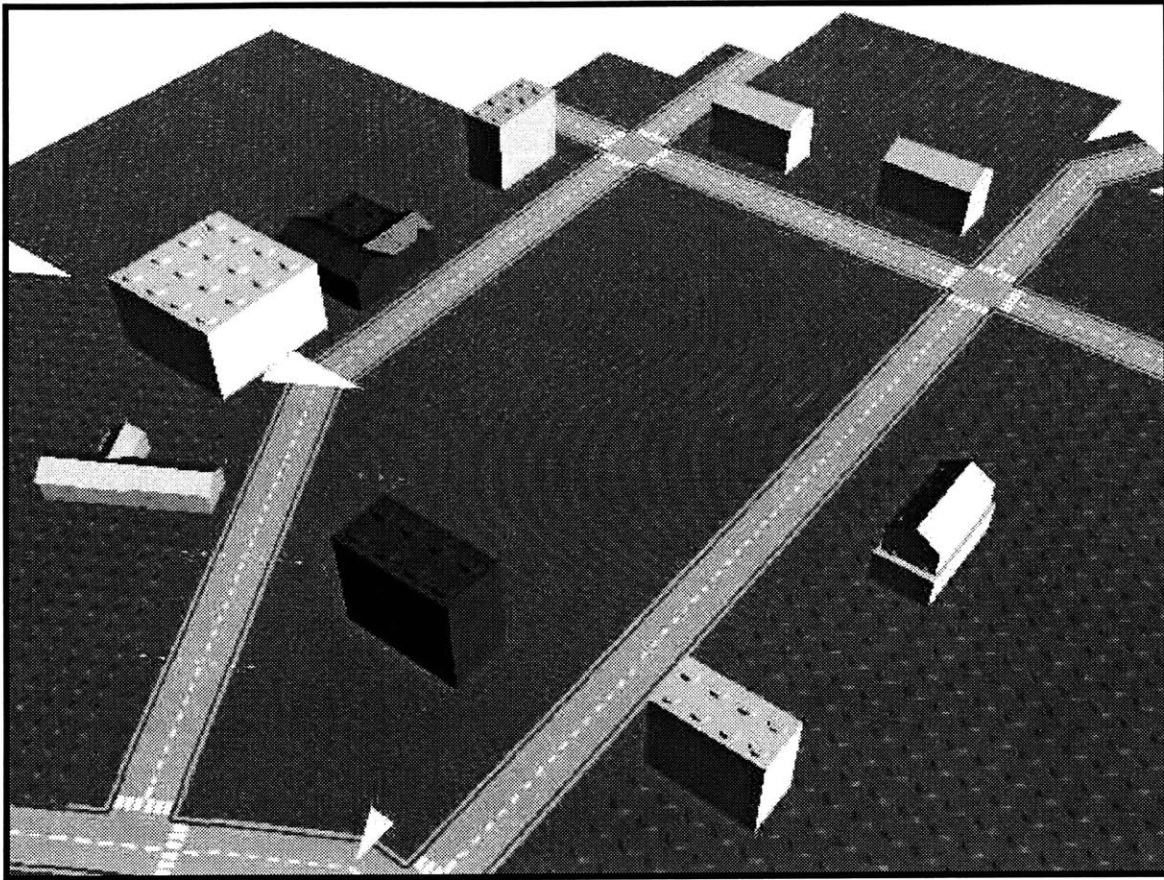
[Figure 20].



**Figure 20: Park and Street Layout Template**

To improve the representation of the surrounding land, the neighborhood organization might find it useful to also model the existing building structures surrounding the proposed site for development. [Figure 21].



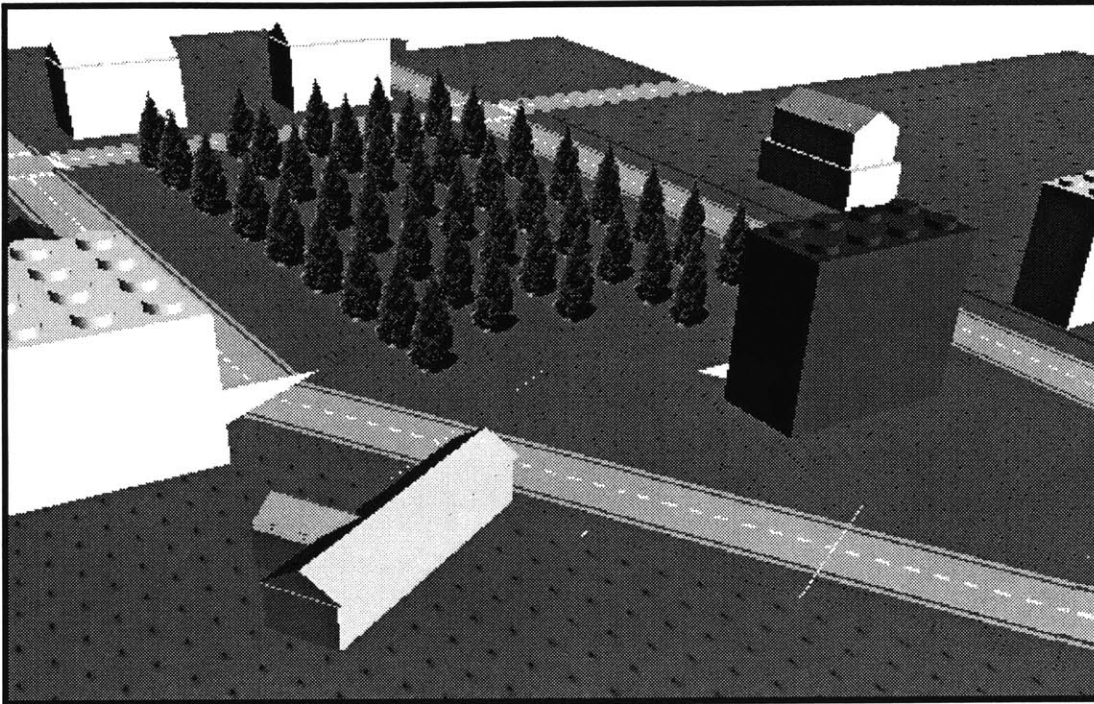


**Figure 21: Virtual Model of Site and Surrounding Buildings**

### *Visualization of a Community Agricultural Use*

Returning to the hypothetical generation of alternatives, a participant might suggest a community garden use to replace the existing open space use. Community gardens are popular because they provide land that can be used by a community for agricultural purposes that may provide economic revenue for residents. A visual representation of what the site might look like if it were turned into a farm for producing Christmas trees is depicted using the Virtual Blocks Authoring Tool. [Figure 22]. The author may have used small blocks to symbolize Christmas trees when working with her physical LEGO™

blocks. When reconstructing the model using the Virtual Blocks Authoring Tool, photo-realistic trees could be inserted in place of the abstract representation to further enhance the visualization.

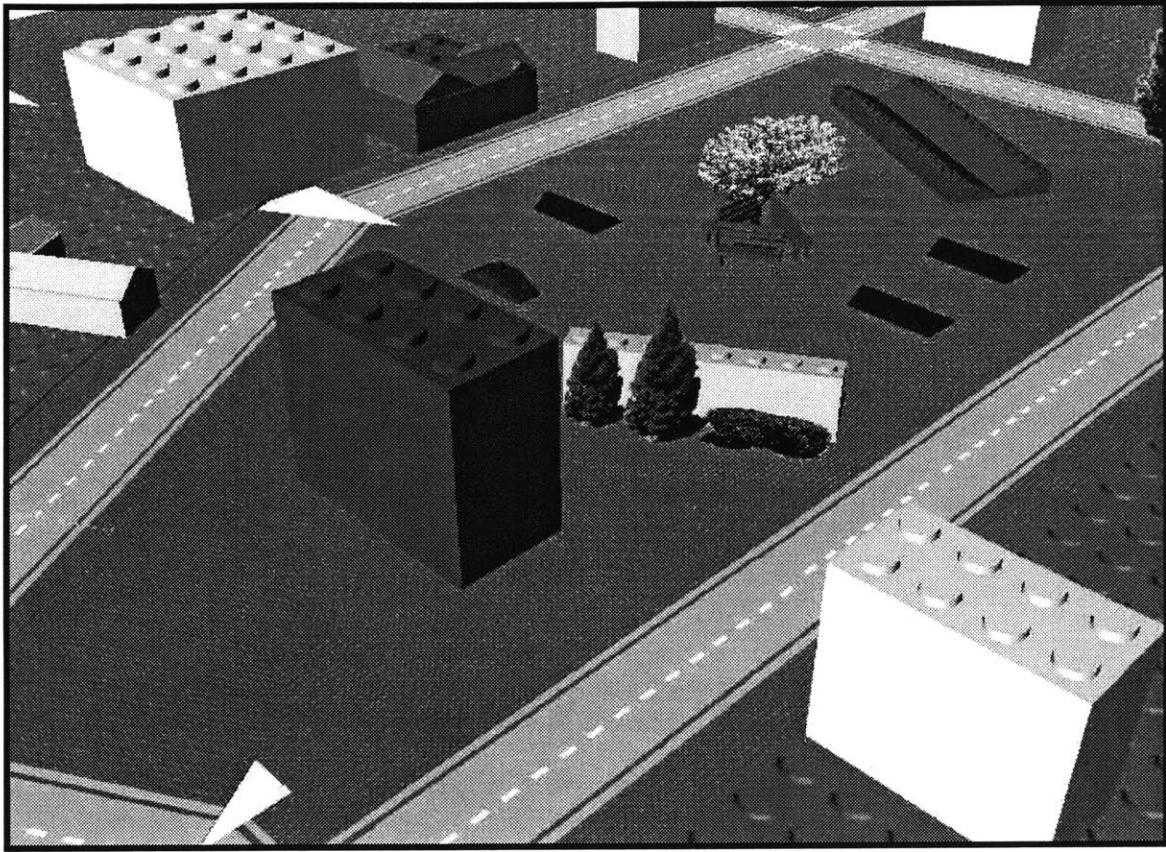


**Figure 22: A Christmas Tree Farm**

### *Visualization of a Skateboard Park*

Since the tools are hoped to elicit participation from as many residents as possible, one might expect alternatives designed by some of the youth residents. Figure 23 depicts a possible alternative for a skateboard and biking park, complete with ramps and a half-pipe. Benches were placed in the center of the park to allow optimal vantagepoints for interested spectators.

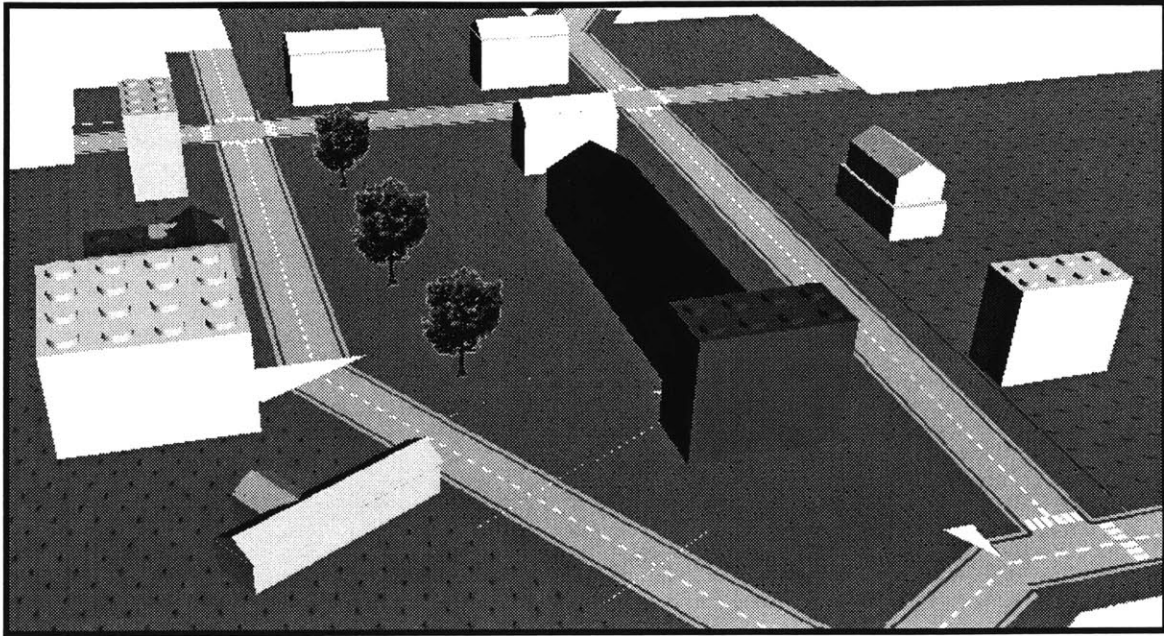




**Figure 23: Skateboard and Bike Park**

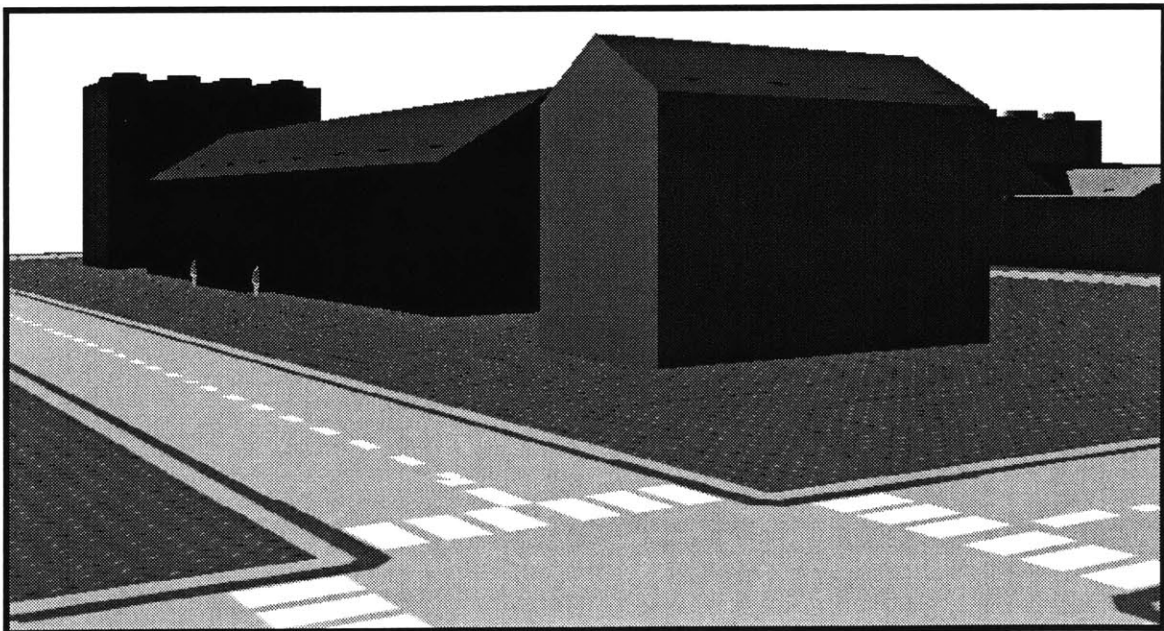
*Visualization of a Housing Complex*

Another example of a potential alternative for the site would be the construction of more housing, including an apartment complex. [Figure 24]. Visualization of the placement of new buildings on the site and the increased density might aid in discussions about this alternative.



**Figure 24: Apartment Complex and Other Housing**

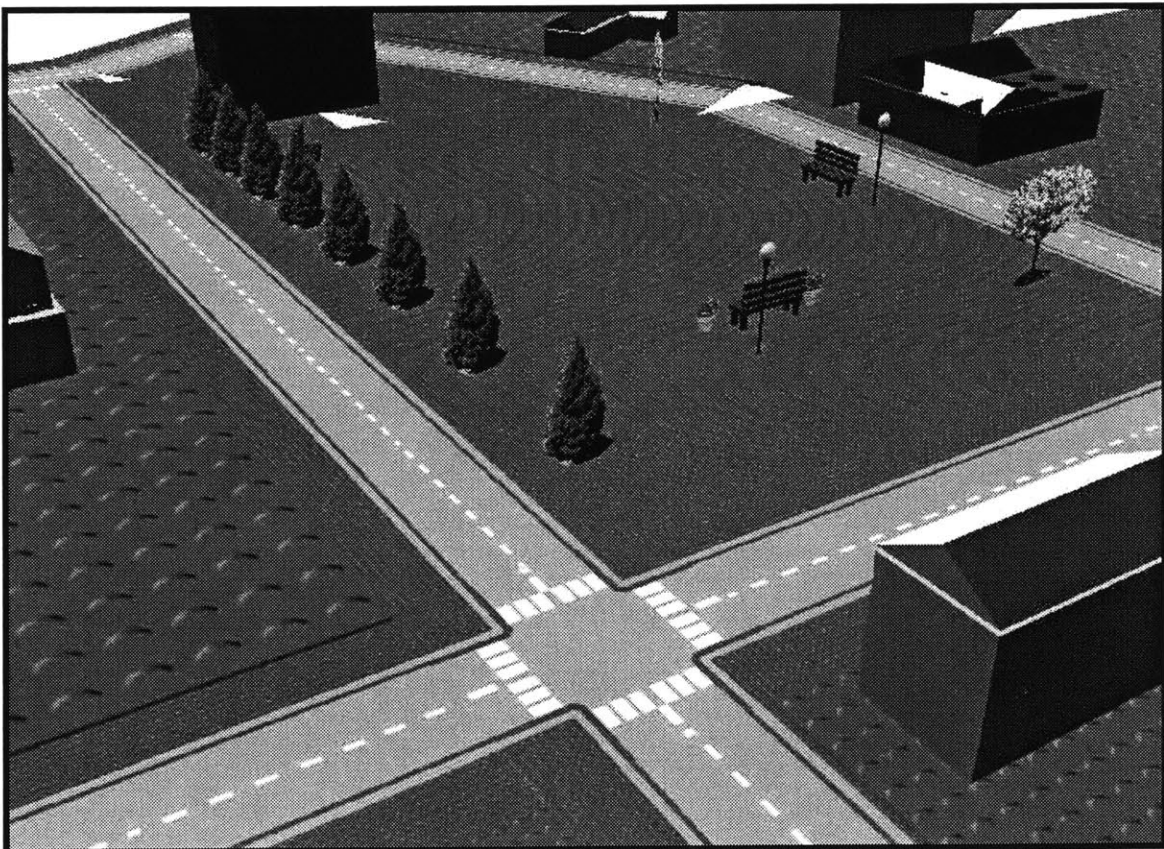
Since virtual models generated with the Virtual Blocks Authoring Tool are not constrained in potential viewpoints, a street level perspective might be useful to visualize.



**Figure 25: Street Level Perspective**

### *Visualization of the Juxtaposition of Several Designs into a New Alternative*

The virtual models generated with the Virtual Blocks Authoring Tool can be directly expanded upon once modeled. Figure 26 illustrates a design that draws from components included in previous alternatives. In particular, the Christmas tree farm was reduced to a single row of trees, and the benches from the skateboard park were repositioned. Having the ability to visualize other community members' design ideas might lead to the juxtaposition of elements from various alternatives into an alternative that meets the needs of several community members.



**Figure 26: The Juxtaposition of Elements from Previous Alternatives**

## **CONCLUSION**

Neighborhood community organizations that strive to incorporate the public's ideas into designs and plans have needed more appropriate tools for vision sharing. This thesis described one possible approach for improving the public's ability to design, share, and evaluate alternatives. In the past, the public's primary role during neighborhood design meetings often was that of 'evaluators,' critiquing those designs that were presented to them. This research attempted to illustrate how new and emerging information technology tools could involve the public earlier in the process of setting the vision for the neighborhood by helping the public better express visually their own design ideas.

## **ISSUES OF ACCESSIBILITY**

Several challenges helped shape the design of the tools. The first challenge was designing a tool that could be used during a short meeting. The tools had to be both productive and easy to learn. The target user group was expected to have little or no computer experience. In addition, many communities are multicultural and require software tools that can be interpreted across spoken languages. When possible, the graphical user interfaces were not spoken language specific, but instead incorporated pictures and icons to symbolize meaning.

Another challenge was to develop these tools for a typical neighborhood community organization. Thus, cost and maintenance of the software were important. Cost factors include training of personnel to manage the software and install it on computers, floppy disks for archiving object movies, a digital camera (~\$600), a “Lazy Susan” turntable (~\$15), a tripod (~\$50), LEGO™ blocks or other physical building tools, and a computer. The computer should be at least a Pentium computer with 64 MB of RAM. Improved performance can be obtained by adding more RAM and by adding a graphics accelerator card. If the neighborhood organization desires the capabilities for the public to participate via the Internet, then costs increase to include more software maintenance and access to a web server.

Not surprisingly, more issues and questions arose after working through the development of some prototype tools. Not only are there future interface enhancement issues, but also questions concerning how the tool could and should be used. The next few paragraphs present some of the continuing issues related to 3D graphics visualization and interaction. Following is a discussion of some of the broader, and arguably more important issues that this research unfolds, such as issues of empowerment, false impressions, and good design.

### **ISSUES OF INTERACTION**

The complexity of interacting within a 3D space presses the need for better tangible interfaces. It is not by accident that this research structures the public’s design process

around building with physical modeling tools, such as LEGO™ blocks. These physical blocks are much easier to work with than their virtual counterparts. Nevertheless, a virtual representation offers more capabilities for visualizing, archiving, and experiencing modeled designs. This research attempts to combine the best of both worlds, by encouraging the user to first build her model with her hands, using physical blocks, and then to replicate the vision as a virtual representation that can be archived and visualized from a number of perspectives.

Future research should smooth out the process of going from physical, to virtual, and possibly back again. The Triangles tool discussed earlier is one of the most promising developments toward this direction. Once LEGO™ bricks equipped with sensors become relatively inexpensive, possibilities of directly interacting with the virtual world through physical model manipulation become more practical. Incorporating input devices other than the mouse and keyboard could enhance interacting with the virtual world. More intuitive interfaces such as those used in gaming environments like that of a car steering wheel and pedals might be useful. Lastly, computer vision and image processing research might support this work. The photos collected during the object movie capturing could be image processed and the geometry represented in the photos could possibly be reconstructed to create a virtual model directly.

## **ISSUES OF TECHNOLOGY**

The object movie representation and the virtual block representation each have pluses and minuses. [Table 2]. Since the object movie consists of a series of JPEG-encoded images, each object movie can be fairly large, on the order of 500 KB. A large virtual block scene, consisting of approximately 100 objects, retains a file size of less than 100 KB without compression. Future improvements on reducing the object movie size might include image processing of the series of images such that only those pixels that change from photo to photo are recorded. This technique would be similar to techniques used to optimally stream video.

**Table 2: Pluses and Minuses of Prototyped Tools**

Stage of Proposed Visioning Exercise	Pluses	Minuses	Improvements	Future Technologies
Designing with Physical LEGO Bricks.	Intuitive, tangible interaction. Rapid alternative construction. Likelyhood of public familiarity with LEGO bricks. Available in toy stores throughout the world.	Physical space limitations for housing constructed models. Limited set of bricks. Perpendicularity of Designs. Need for creating digital archives to reuse bricks and allow for comparisons.	Better integration of digital information with physical objects.	Juxtaposition of Triangles Technology from Ishii's Tangible Bits Group with Resnick and Papert's Cricket Technology to create Tangible LEGO interfaces to digital models.
Object Movie Creation	Provides a digital archive of physical models. Captures several perspectives of the model and allows for zooming in and out. Can be annotated with comments and evaluations.	Requires the use of a digital camera, which can constrain the meeting process to occur at a 'fixed time and fixed place'. Fixed number of viewpoints on the model. Viewing only capabilities; not a tool for digitally modifying actual objects in the scene.	Automated translation of photo images into 3D geometry for insertion into virtual worlds. Digital motion video capture for smoother, faster input.	Image processing algorithms for geometric reconstruction.
Virtual Scene Authoring	Infinite size possibilities of virtual world. Infinite viewpoints of the model, including simulation of standing at ground level within the model. Ability to modify digital models in real time, expanding on archived designs.	Less intuitive interaction. More time consuming than working with physical blocks directly.	Better coupling of digital scenes with physical blocks, for improved interaction. Expanded library of digital objects. Other more intuitive navigation tools.	Haptic interfaces such as the pHantom. Incorporation of 'Steering Wheel and Pedals' game type navigation controls.
Annotation and Public Review Process	Allows for the sharing of perspectives and the juxtaposition of various alternative visualizations.	Difficult to predict the flow of design decisionmaking once alternatives are generated.	Need for better filtering of alternatives, ranking systems, and ultimate decision making strategies.	Computational processing of models to organize 'similar' models and present summary statistics of repeated design features among alternatives

At the time of writing this thesis, current Internet browsers would not support the applet without the Java Plugin. The Java Plugin, once added to the browser, enables the browser to always use the most recent version of the Java Virtual Machine, which interprets the Java programs. This requires a separate download and installation. Additionally, since the Java3D API is not packaged with the standard Java Runtime



Environment, another separate download and installation of Java3D currently is necessary. While deployment issues currently require a fairly high level of technical knowledge, one should expect that these issues would be resolved within the near future as Internet browsers begin to catch up to the latest possibilities this technology affords.

### **ISSUES OF FALSE IMPRESSIONS**

Any abstraction of reality can lead to false impressions and misguided expectations. For example, a LEGO™ model of part of a neighborhood may create a distorted view of the actual conditions of that neighborhood. LEGO™ bricks are very uniform, smooth objects. A model might create a false impression of the condition of buildings in the area, the topography of the land, or the suitability of the land for different alternatives. Thus, care must be taken to not leave out other useful information that describes the actual conditions of the neighborhood.

Even when adding realistic objects, such as the photo-realistic trees incorporated into the Virtual Blocks Authoring Tool, a potential for creating false impressions of what is really possible for a site exists. For example, scaling the trees to represent fully-grown trees might be a misleading vision for how a park might actually look when actually landscaped. Similarly, certain types of trees might physically be unable to grow on a particular site due to soil or climate conditions. Finally, budget constraints might place real limits as to which alternatives are actually possible for a neighborhood to implement. These concerns should be highlighted at the start of the design process to help ground the

public in reality, and minimize the effects related to public disappointment due to unobtainable alternatives.

## **ISSUES OF IMPACT**

While the effects of these tools on the public participation process and ultimately the proposed design of a neighborhood won't be known for several years, some important issues should be presented and questioned. First, there is a fundamental question as to whether empowering the public as designers will lead to good design or not. Avoiding deeper philosophical questions as to what exactly is a 'good' design, it becomes important to note that both the public and the professional designer have something valuable to offer. Empowering the public with the ability to visually express their ideas and rich neighborhood knowledge should help the communication process between professional architect and the public.

Introducing visualization tools that utilize LEGO™ bricks as a design medium may not be well accepted by all people involved. Suggesting that people 'play' out their ideas with toy blocks might be insulting or almost condescending to some participants. Thus, a neighborhood organization should take care in introducing these tools. An organization might want to introduce these tools by first providing a demonstration of how the tools can really be used to convey planning thoughts and visualizations.

In addition to a concern for the public's reaction to these prototyped tools, the willingness of participating consultants or architects working within this process need consideration. The software tools are designed to help the general public visually convey their ideas. The neighborhood organization should not expect all professional consultants to be open to this type of public empowerment process. Finding progressive thinking consultants to work within this framework may be challenging. Before beginning the design process, the neighborhood organization, the public, and the selected design consultants should communicate their expectations regarding the incorporation of ideas into the final design.

While these tools are hoped to provide a more meaningful, collaborative, and engaging design process for the participants, the possibility exists that participants will become more divided than together on the issues. As soon as one becomes a builder of a model, there is a certain level of ownership related to that model. While this sense of ownership can lead to deeper involvement and potentially better designed alternatives, the possibility of conflict increases when someone else challenges the design that a person put a lot of time and thought into. Thus, structuring the meeting such that all of those involved clearly understand the meeting process of build, evaluate, and re-build can be critical to this type of design environment.

A final important issue related to introducing a new tool such as those developed in this research is to reflect on who among the potential participants is now included in the design process and which voices have been excluded. Hopefully, such a tool will increase the public's ability to both participate and visually convey their ideas. Providing

Internet participation expands the reach of the community meeting into asynchronous communication channels, allowing those not present at the meeting to participate. On the surface, one might speculate that the architect or professional designer's participation is weakened by this change in process. However, the professional's ability to design, theoretically, should be improved as the knowledge of the community's wishes are better understood. Since it is always difficult to predict who will feel alienated when the tools of expression change, community organizations that wish to incorporate new and emerging technologies into their meetings should also try their best to retain the old forms of communication and idea expression that may have worked better for some.

#### **POTENTIAL FOR RENEWED PUBLIC EXCITEMENT IN NEIGHBORHOOD PLANNING**

The public participatory design tools and methods have the potential to get people excited once again about their community. The tools put the planning design and decision-making into the hands of the public. Providing the public with engaging, interactive tools that allow them to construct their own visions for the future can provide a new dynamic within the planning process. This dynamic empowers its participants by making each individual an active and integral part of the creative problem solving efforts within a community. While this research outlines a new approach for vision expression, the tools alone do not make the planning process more engaging. Rather, it is the excitement from the people using the tools and the personal satisfaction that this new empowerment affords to individuals as they realize that they have contributed to the solution.

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