GRAHAM SUSTAINABILITY INSTITUTE
UNIVERSITY OF MICHIGAN

3D Visualization Software Improvement for Co-designing Community Open Space

Team members

Kidus Admassu, Master of Civil & Environmental Engineering
Ayush Awadhiya, Master of Business Administration
Gwen Gell, Master of Urban Planning & Master of Urban Design
Saebom (April) Kwon, Master of Science of Information
Shannon Sylte, Master of Landscape Architecture

Faculty Advisor

Mark Lindquist, Assistant Professor, School for Environment and Sustainability
Robert Goodspeed, Assistant Professor, Taubman College, Urban and Regional Planning

Table of Contents

Executive Summary

Engaging diverse stakeholders in decision making around urban planning and design is critical to building more sustainable, socially-just communities. Open space design is a medium through which residents can actively engage in shaping the environment to meet community-specific needs. Generally, open space planning and design practices use a top-down approach beginning with city officials, planners, and designers, and ending with community engagement. Current 3D visualization and design software is developed to include a level of technical detail necessary for built environment professionals. The level of skill required to use design and visualization software makes them inefficient to use as community engagement tools. This project looks to enhance community engagement around open space design and planning with user-friendly software accessible to all stakeholders, from residents to professionals. We provide a model for shifting the practice of open space design to engage stakeholders early in the planning process using interactive software to document residential open space design needs. This project showcases a unique combination of methods, in-person participatory activities coupled with improving a new software-based planning support system, Land.Info, to reimagine a vacant lot in Detroit, Michigan. In addition to evaluating the participatory method, this project assessed if providing environmental and economic feedback of the proposed designs, through Land.Info, impacted design decision-making. This combination of methods was examined over a series of three workshops, to explore whether Land.Info could be combined with traditional planning techniques to realize community driven design concepts.

Collaborating with the Detroit-based Eastside Community Network's (ECN) skilled community-outreach team, the Dow Sustainability Master's Fellowship Team (Dow Team) supported residents in the co-design of a community open green space while developing visualization software. Additionally, the project focused on identifying incremental improvements to the co-design user experience through the development of Land.Info. The technical improvements to this software provide a common visual language between residents and community decision makers leading to more effective and efficient collaboration in the co-design of sustainable urban environments. By leveraging the group's expertise from the School of Information and School of Civil Engineering, Land.Info was improved in terms of: 1) interface design; 2. ease of use; and 3. environmental sensor deployment.

To inform improvements around the interface and useability for users of Land.Info, a three-part analysis was performed by the Dow Team. Results from a comparative analysis, internal heuristic evaluation, and usability tests indicate:

- Environmental parameter and cost analysis is not salient for users
  - Analytics visualization should be more visible
- Non-expert users utilize a variety of media (drawings, software representations, conversation) to support their design argument

  - Land.Info should collect more user-generated 'raw' data including photographs, drawings specific notes, site specific stories, audio, video
- Users are confused by unfamiliar controls and visual indicators
  - Land.Info should consider more familiarity and ease of use in the software

The environmental sensor development and deployment was integrated into the software to provide site-specific data to inform design decisions. The sensors were programed to collect site-scale environmental data from wireless sensor units. These data may be used to quantify specific performance benefits of the community green space, both before and after implementation. Environmental data from a given open space is essential in helping to understand the performance benefits of the open space design. Data collected included air quality and ambient sound and motion, which can now be visualized in the Land.info software to provide users with an understanding of how the design is actually impacting current air quality, noise, and site use levels.

This report details the process of collecting and refining user experience data, the creation of integrated sensors to collect site-specific data, and future recommendations concerning user experience and sensor integration for Land.Info. The improvements to to and recommendations for Land.Info further informed collaborative designs and contributed to the efficacy of this software as a participatory design tool.

User Interface Design

Background

Well-designed, seamless user interface design effectively increases user engagement in the software. To achieve this, user-centered software design invites users to engage in the design process to understand their needs and the environment in which they will use the software. This design principle especially resonates for Land.Info when considering the software's aim to position itself as a participatory planning tool that brings diverse stakeholders together in the planning and design process. Through client interviews, we identified that the key feature of Land.Info is to provide realistic 3D space visualization, and environmental cost-benefit measure. Therefore, an overarching goal of our project is to understand different user needs and gain insights to enhance main features based on the input from potential stakeholders. The research team asks the research questions as below:

1. How do design experts and non-design experts interact differently with software?
2. How can Land.Info strengthen the main features for participatory space design process?

Methodology

Over last year, our team performed four different usability evaluations to come up with concrete, actionable recommendations for the software developers. First, we conducted a comparative analysis to seek out competitors that offer similar main capabilities of Land.Info and investigate whether certain valuable usability features could cross over to Land.Info. Second, we conducted five in-person software user testings with design experts, which include one heuristic evaluation (Nielsen & Molich, 1990) and four usability testings (Dumas et al., 1999). Lastly, we organized three community resident design workshops to see how the general public users respond to the software. We provided the software development team a recommendation report regarding unique user behavior/feedback and usability issues after each testing for the concurrent development process. We attached a more detailed plan for each testing in Appendix 2.

Phase 1			Phase 2		Phase 3	
Comparative Analysis	Heuristic Evaluation	Analysis & Implementation	Usability Testing	Analysis & Implementation	Community Workshop	Analysis & Implementation
Mar 2018	April 2018		July 2018		Sep - Oct 2018	

Figure 1. Project timeline for user interface design

Results and Recommendations

1. Environmental-impact and cost-estimate feedback metrics are not salient

Throughout the testing, urban design experts and non-expert participants, regardless of design experience, appreciated the environmental metrics analysis and cost estimate feature of the software. Particularly, all four practitioners assessed the promise of the software that supports real-time cost estimation so designers can quickly check the estimated values while they design. Based on our comparative analysis, this feature is currently available in some consumer-based 3D visualization software. However, they focus on either the quality of 3D graphics (design-focused) or comprehensiveness of the analysis (analytics-focused). We also identified that professionals are interested in how accurate and up-to-date the data is. All of the participants asked about the calculation methodologies and accuracy of the datasets. For general public use, most of the analytics software often involve the tradeoffs of uniform analysis results for specific parameters that enable the public to understand the data. CommunityViz, for instance, has more than 100 sustainability measure indicators and users must sometimes 'mine' variables to find relevant data. Therefore, curating right parameters that the user seeks from the software would be the key for the Land.Info development team.

Recommendations: Set a designated space for analytics in the software

We recommend Land.Info to enhance analytical visualization by first defining parameters based on user groups and reconsidering data visualization options. For instance, Detroit, which has a large concentration of economically underserved residents, might want more information on maintenance costs and economic development impacts of the designs. Likewise, Land.Info team should identify locality-specific, stakeholder-specific data needs, and the software should equip more flexible parameters based on the user tasks. Also, when displaying environment feedback analysis, the software can increase user engagement by reserving a designated space within the interface for analytics. For example, CommunityViz and Urban Footprint, which have rigorous analytic features, separate the visualization panel and analysis panel so users can apply and recognize the changes simultaneously. The results indicate that Land.Info should consider these factors as long-term goal in the development of this software.

2. Non-expert users utilize different types of media to support design argument

3D visualization was engaging for resident participants in a way that it prompted them to conceive narrative-based ideas based on the visualization. For example, we provided the participants in the third workshop a set of printed screenshots of design outcomes from the previous workshop. Many times, the participants referred the design printouts to explain their ideas so they could use a visual reference. Furthermore, they often utilize analogies and use case scenarios to bolster their design arguments. A newly designed note tool in the design workshops was used a number of times to note the varied options the participants mentioned.

Recommendations: Land.Info should collect user-generated data

The research team argues that Land.Info will be able to collect richer, more useful data from the sources by giving non-technical experts multiple media to communicate ideas with the public. While past literature emphasizes the effectiveness of translating complex spatial information into more clear visual, non-technical language (Innes & Simpson, 2000), researchers also point out that the simulation can mislead ordinary residents (Talen, 2000). Although the current 3D space simulation shows a realistic view of the site, it might not be able to fully incorporate different user views and other media such as text, graphic images, digital video, and sound. Incorporation of these features would help users to feel engaged as well as provide more evidence to support design development.

3. Users get confused by unfamiliar controls and visual indicators

Currently, Land.Info uses Keyboard-Mouse controls so a user can make transition between Move mode and Perspective rotation mode, following most simulation game environments. However, our usability testing results revealed that none of the participants did understand the control without moderator instruction and all had difficulty to get familiar with going back and forth between the controls. Moreover, all the competitors we examined use mouse controls with just some of keyboard shortcut options. This issue was amplified in the resident workshops where the participants are not familiar with design software and keyboard-mouse control, and this led the team to decide to have moderator-controllers who control the software for the participants. Finally, we identified that some the visual indicators mismatch with user mental models and most of the time delay for tasks sprang from unfamiliar icons. For instance, the software's 'Undo' button is the same as 'Rotate Left,' and 'Redo' button as 'Rotate Right'.

Recommendations: Land.Info should consider more familiarity and ease of use

The research team feels that this recommendation might be the most salient one regarding enhancing the usability of the software and namely to improve user design experience. Current control might be familiar to users who are used to game controls. However, we recommend Land.Info to either 1) remove transitory control and only allow mouse control so a user use a wheel to zoom in/out, and the right click to change the view, or 2) more clearly state current control to the users by showing the transition status in the home screen. Furthermore, provide users with familiar, universal icons will give them more confidence while they use the software. During the project, the research team offered the development team a set of redesigned icons and the template for adding new icons, the complete set of redesigned icons is attached in Appendix 3.

Discussion

Overall, the sets of usability testings and user engagement workshops provided the research team insights about different behavior and expectations around Land.Info based on the userd. During the project, the research team identified several fundamental usability issues of lacking return/undo function, visibility of system status, inconsistent controls and visual indicators, lack of help and instructions in the software, most of which were addressed throughout the project timeline.

Environmental Cost and Benefits Analytics

For both urban practitioners and the public, environmental cost and benefit analysis feature was the most useful feature. To strengthen the feature, we think that the sustainability measurements that the competitor products are using are too comprehensive for public users to grasp and it will be crucial for the Land.Info software design team to make the software flexible for users to import their own dataset or parameters to customize the software for their domain tasks as well as the analytics feature should be more emphasized to attract more users.

3D Simulation in Design Discussion

Realistic 3D simulation and interaction of the software is another central feature of Land.Info that can put the software stand out from other existing software. This allows non-design expert users to more easily understand a physical site. Land.Info would consider diversifying media formats so planning participants can have more holistic site experience. This was also a suggestion from urban design practitioners as well, as one designer suggested it would be helpful if she could import their 3D object models and their datasets so they can present them to clients.

Familiarity and Accountability

Our results also indicate that the software should provide more familiar interface for users so they can more easily adapt the software. During the tests, the participants expected the similar degree of functionalities and often referred familiar features from other 3D design software. For enhancing accountability of the information, Land.Info can put the additional information about their methodology on the screen so users can get information regarding the basis of software analytics.

Limitations and Future Steps

Our small sample size might not be generalized to the broader user population. While quantitative data was collected and measured during all of the testings and design workshops, the study was mainly qualitative. It provided the research team some systematic insights that are hard to discover from the quantified performance and success rate. In the future, Land.Info can enhance their accessibility by developing a mobile application for crowdsourced design aggregation. Furthermore, it can be utilized in group discussion, as well as effective facilitation tool in in-person design workshops. The actionable plan for these potentials will be further discussed with the developer team.

Environmental Sensing

Background

Environmental data used to inform landscape design often comes at the local and regional scale from openly available sources and does not account for variation at the ground level. Collecting site-scale data is time and resource intensive, leading practitioners to design without detailed information regarding site-specific variations in the landscape. Environmental design professionals such as planners, engineers, and landscape architects are interested in streamlining site-scale data collection to better understand the variation in the landscape and more accurately design and measure and/or monitor a design's impact using different kinds of sensors. Data of interest include: infiltration rate, soil texture, stormwater, air quality, asthma triggers, dust from highway and motion. Furthermore, these can be grouped as: stormwater and infiltration measurement, air quality and asthma triggering pollutants measurement, and motion detection. Acquisition of site-scale environmental data offers the opportunity to design and monitor open spaces that more accurately report the environmental and public health improvements resulting from an installation.

Information such as: temperature, humidity, precipitation etc. are readily available from open sources but generally varied within a sizeable area, like a neighborhood, city or region. Data related to air quality, dust/particle concentration, sound, pedestrian movement etc. greatly vary from location to location. Thus, it makes these data af study interest of this project in parallel to landscape visualization software improvement in that it will allow for more informed design decisions to be made within the software.

Sensor Use Cases for Environmental Applications

Adequacy of storm-water drainage system can be monitored with different strategies. One is measuring water percolation the soil. Availability of water to plants is also important. Thus, a Double Ring Infiltrometer (DRI) can be used for measuring the rate (based on Darcy's Law) at which water infiltrates to soil.

A standard set of the DRI consists of a number of sets of stainless steel rings with different diameters. Several measurements can be executed simultaneously, yielding a very reliable and accurate result. As vertically infiltrated water runs to the sides, the outer ring of the Infiltrometer serves as a separation. The measurements exclusively take place in the inner ring through which the water runs virtually vertical (Eijkelkamp, 2018). Several factors affect infiltration measurement. The major ones are: surface vegetation, extent of soil compaction, soil moisture content and soil layers (strata).

For communities living alongside roads, health concerns related to air quality are important because health effects are evident to populations spending significant amounts of time near high-traffic roads (EPA, 2016). These effects may be attributed to increased exposure to particulate matter, gaseous criteria pollutants, and air toxics emitted by vehicle activity on the road. So generally, pollutant mitigation strategies are attributed to: vehicle emission control techniques, air quality management programs, reduce impacts from brake and tire wear and re-entrained road dust, preservation and planting of roadside vegetation, and construction of roadside structures such as noise barriers.

Before making important decisions in constructing barriers, the thresholds of air pollutants such as O_3, NO_2, SO_2 and CO must be quantified. Since it is evident that pollen and dust trigger Asthma, additional air polluting compounds shall also be measured.

Open spaces cooperatively designed with landscape architects, communities, government authorities, business owners and nonprofit organizations helps to. The optimal location of bus stops with shelters and bus route information is also essential to design along corridor like Mack Avenue. After construction of such facilities, it is of interest of the designers to see the utilization rate. Usually, this is done via manually counting people entering or arriving at a facility To identify the activity on the site, simple motion sensors, with no video capabilities, are adequate.

Methods

Types of Sensors in Use

The following kinds of sensors (see Figure A1) are interfaced to an Arduino Uno board and packaged in to a water tight sensor box. The descriptions for each are as follows:

Dust (Particle) Sensor

Particle concentrations are quantified in $\mu g/m^3$ and the sensor that is used is HPM Series Particle Sensor from Honeywell. The sensor has concentration measurement range of 0 to 1000 $\mu g/m^3$ with an output analog voltage of (0 to 3.3 V)/ 5 V (Honeywell, 2018).

Gas Sensor

An air quality or gas sensor from Amphenol is proposed to be used. The sensor has a capability to report different kinds of gases and it operates well in – 30 to 85 °C temperature range. It detects the gases CO, NO_2, C_2H_5OH, H_2, NH_3, CH_4, C_3H_8 and C_4H_{10} and eventually outputs 0 to 5V analog measurement (SGX Sensortec, 2018).

Motion Sensor

There are different kinds of motion sensors. The major ones are: Passive Infrared (PIR), Ultrasonic, Microwave and Tomographic. The PIR sensor includes a thin Pyroelectric film material that responds to IR radiation by emitting electricity. It is economical and it does not use more energy and lasts forever (Elprocus, 2018). So for this project, we considered PIR sensors for the low cost, low power consumption, and suitability for identifying people movements as opposed to objects. It has a sensing range of 5 to 10 m and detections are read as analog voltage output of 0 to 5.5 V range (Panasonic PaPIRS, 2018).

Sound Sensor

An analog sound sensor SKU: DFR 0034 is used to detect the loudness in ambient. Detected sound intensity is then read as analog output of 0 to 5 V range.

Interfacing

Arduino Uno

The Arduino is an open-source hardware, software and content platform with a global community which is intended for anyone making interactive projects (Arduino, 2018). The hardware contains a microcontroller with a processor, memory and programmable input and output peripherals. This enables the Arduino interface sensors in an integrated development environment. For this project, we will be using the *Arduino Uno* board which combines a microcontroller along with all of the extras to make it easy for us to build and debug our project.

Data Transmission

The Real-Time application and communication of the Arduino Uno board is of prime importance. The Real-Time application goes to the cycle of data acquisition that is going to be discussed in the next section while the Real-Time communication is going to be conducted by employing a 4G-LTE internet shield from an Italian company called TELIT (see Figure A2). Thus, the data is communicated in Wireless to a website portal or personal accounts (email or text messages).

Results and Recommendation

Data Acquisition and Relevance to the Land.info Software

Air quality, dust/particle concentration, sound and motion are to be monitored using the commercial sensors by interfacing to the Arduino Uno board, as presented above. The Arduino samples and interprets data from the sensors and as well work with data transmission platform to push data wirelessly to the internet every hour. Before pushing the data to be accessed by the user, sampling and data preparation is done in the microprocessor of the Arduino (see Figure A3).

Environmental sensor data of a given open space is essential in helping open space design efforts identify which parameters of the environment at the locale should be addressed for improvement. As a result, environmental data such as air quality, sound and motion are planned to be incorporated in the tool to enable users design open spaces being well informed about the site. For instance, as explained earlier, the output from a motion sensor is the percentage of time a certain open space is accessed by people. Knowing this, tool users may include plenty of seating when designing the open space. Additionally, the sound and air quality sensors will measure noise pollution and air pollutants from a site respectively. If these measurements happen to be higher, putting trees around the open space may be a good design intervention.

Future Steps

Sensor Deployment

Once packaging sensor components (such as: commercial sensors, battery, interfacing board, air inflow and data transmission channels) is completed (see Figure A4), deployment of sensor will be conducted. The deployment is made by installation of the sensor box to a firm platform to report data for few days.

Incorporating Data into Land.info Software

As a future plan, before open space designs are conducted using the software tool, environmental data about the site can be availed in the user interface of the tool, in addition to the basic geometric and land use information. As explained before, this helps in making good decisions while incorporating model objects to an open space in question.

Anticipated Impact

The UX design recommendations from the research team has been addressed throughout the project timeline and increased the usability of the software. Furthermore, with the availability of environmental data from the sensors incorporated into the enhanced user interface of Land.info, design decisions by users is anticipated to be shaped by the condition of the ambient environment. The ambience of the site is monitored using the sensors for thresholds of noise, air pollutants and dust particles at point of interest in addition to detection of people's movement in close vicinity. This will highly contribute towards improving object placement decisions in conducting participatory open space designs.

References

Arduino 1 (2018), *"Arduino Education"*, Retrieved on 05/13/2018 from: https://www.arduino.cc/en/Main/Education.

Arduino 2 (2018), *"Arduino Uno Rev3"*, Retrieved on 05/13/2018 from: https://store.arduino.cc/usa/arduino-uno-rev3.

Dumas, J. S., Dumas, J. S., & Redish, J. (1999). A practical guide to usability testing. Intellect books.

Hassenzahl, M. (2004). The interplay of beauty, goodness, and usability in interactive products. Human-computer interaction, 19(4), 319-349.

Eijkelkamp Soil & Water (2018), *"Double Ring Infiltrometer"*, Retrieved on 05/16/2018 from: https://en.eijkelkamp.com/products/field-measurement-equipment/double-ring-infiltrometer.html.

Environmental Protection Agency (2016), *"Recommendations for Constructing Roadside Vegetation Barriers to Improve Near-Road Air Quality"*, EPA 600/R-16/072, Washington, DC.

Honeywell (2018), *"HPM Series Particle Sensor",* Retrieved on 05/19/2018 from: https://www.mouser.com/datasheet/2/187/honeywell-hpm32322550b-1275408.pdf

Kukka, H., Pakanen, M., Badri, M., & Ojala, T. (2017, February). Immersive Street-level Social Media in the 3D Virtual City: Anticipated User Experience and Conceptual Development. In CSCW (pp. 2422-2435).

Nielsen, J., & Molich, R. (1990, March). Heuristic evaluation of user interfaces. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 249-256). ACM.

Panasonic PaPIRS (2018), *"PaPIRS Motion Sensor – Analog/Digital Output"*, Datasheet, Retrieved on 05/20/2018 from: https://www3.panasonic.biz/ac/e_download/control/sensor/human/catalog/bltn_eng_papirs_final_amn.pdf.

SGX Sensortec (2018), *"MiCS-6814 Air Quality MEMS Sensor",* Retrieved on 05/19/2018 from: https://www.mouser.com/datasheet/2/18/1143_Datasheet-MiCS-6814-rev-8-1144828.pdf.

Talen, E. (2000). The problem with community in planning. Journal of planning literature, 15(2), 171-183.

Appendix 1. Images

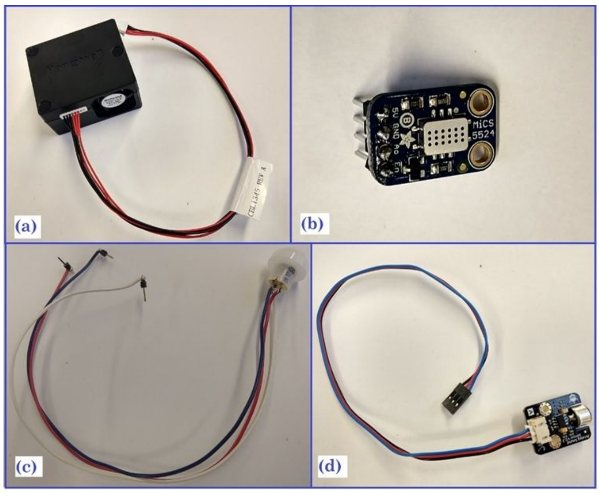

Figure A1. Hardware of Sensors in use (a) Particle sensor; (b) Air quality sensor; (c) Motion sensor and (d) Sound sensor.

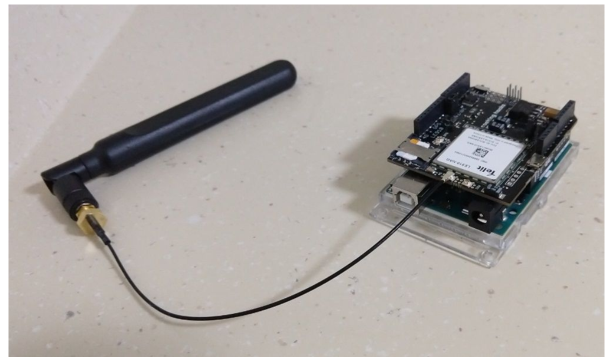

Figure A2. Internet shield (with Antennae and AT&T 4G LTE Sim Card) plugged on top of an Arduino Uno board

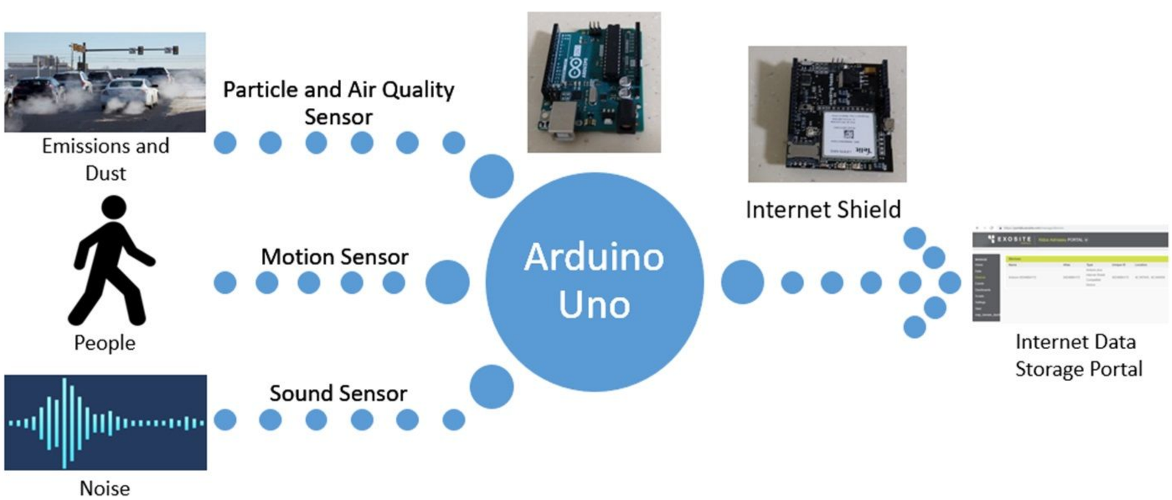

Figure A3. Overall data acquisition flow chart

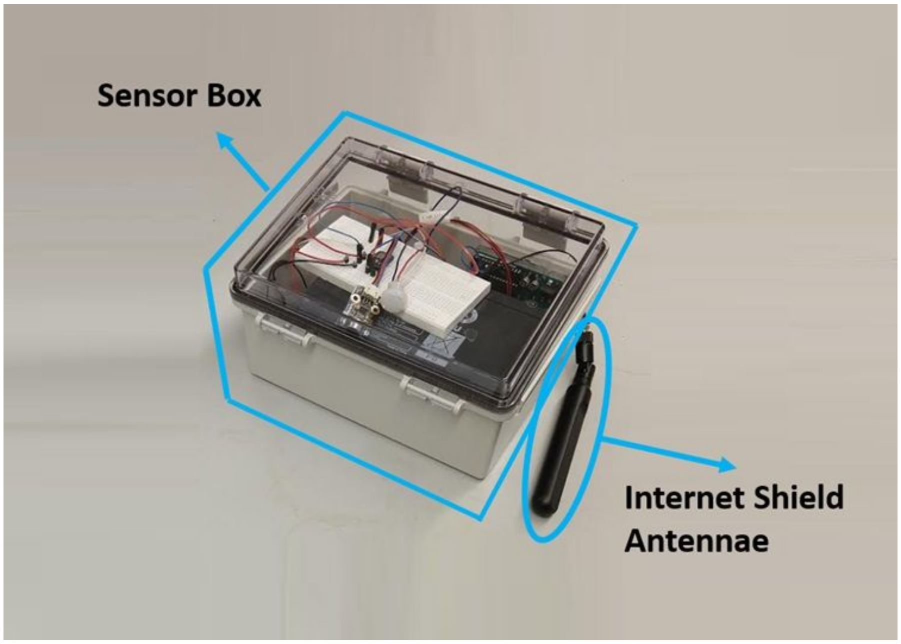

Figure A4. Wireless sensor node packaged and ready for deployment

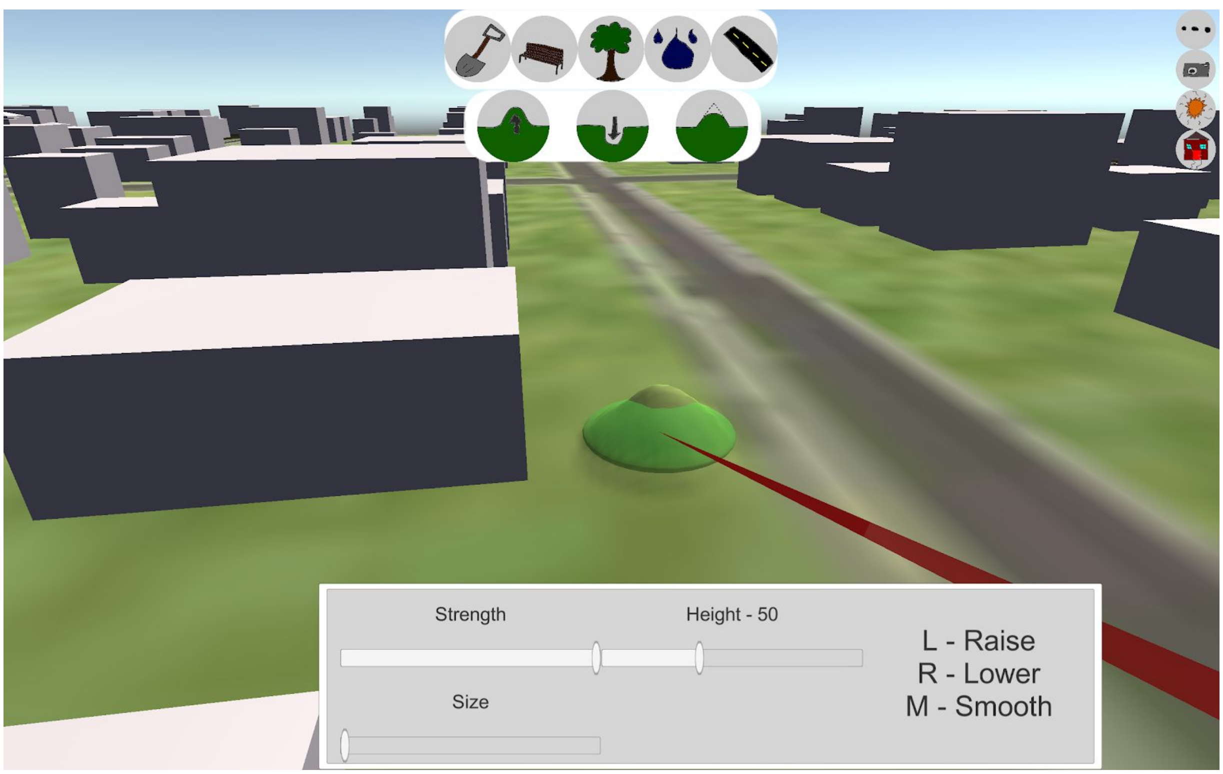

Figure B1. Screenshot of Land.Info (January version)

Figure B2. Screenshot of Land.Info (October version)

Appendix 2. User Experience Analysis Methodology

1) Comparative Analysis

We have asked landscape architecture students who they think Land.Info's competitors. Based on their feedback, we selected and analyzed five existing space design and urban planning software: CommunityViz, Urban Footprint, ArcGIS CityEngine, SketchUp, and Simcity game.

Direct competitors: Provide generally the same functionalities as Land.Info
- CommunityViz is a ArcGIS extension that allows users to 3D visualize and analyze a site
- Urban Footprint is a cloud-based urban planning software that provides geometric 3D view and multi-metric analysis for urban practitioners

Partial competitors: Provide some of the same functionalities as Land.Info
- ArcGIS CityEngine a 3D city modeling software based on GIS data
- SketchUp is a customer 3D modeling tool used for wide variety of fields such as architecture, engineering, and design

Analogous competitors: Non-competitors that provide insight
- SimCIty is an open-ended city-building video game that allows users to place city infrastructure and manage the city based on the budget

	Direct		Partial		Analogous
	CommunityViz	Urban Footprint	ArcGIS CityEngine	SketchUp	SimCity (2014)
System Format	ArcGIS Extension	Cloud-based Web application	Desktop Application (Windows/Mac/Linux)	Desktop Application (Windows/Mac)	Desktop Application (Windows/Mac)
Price	Commercial $1,500, Government/ Non-profit $875, Academic $1,000	Professional $500/month, Team $417/user/month, Civic/Non-profit/Academic (Contact-based)	Basic $500 Advanced $4,000	Free, Pro $695	$29.99
Level of Expertise	Expert	Expert	Expert	Beginner - Expert	Beginner
Control	Mouse	Mouse	Mouse, CLI	Mouse	Mouse
2D Plan	O	O	O	O	X
Map	O	O	O	O	O

3D Plan		O	O	O	O	O
3D Object		Partially (Import as packaged file, visibility on/off)	X	O	O	O
Sustainability Analysis		O	O	X	X	O
Calculation Measures		About 100 indicators on land use, demographic, transportation, environment, housing, employment	Land consumption, Energy, water, accessibility - walk, accessibility - transit, transportation, emission, household cost, resilience			City Rating, Population, City Development
Environment	Tree	O	X	O	O	O
	Green Infrastructure	X	X	X	X	X
	Atmosphere	O	X	O	O	O
Importable file format		Formula, map	Map, Shape	Map, 3D models (OBJ, DAE, DXF, VOB, FBX), KML, Shape	CAD, KMZ, 3D models (3DS, FBX, OBJ)	X
Exportable file format		Scenario 3D, ArcScene, Google Earth/ArcGIS	CSV, SVG	SLPK, KML	CAD	X
Additional Features		Comparative analysis based on Scenario 360, scenario planning	Scenario planning, Map styling	VR Export support	VR Export support	

Table B1. Comparative analysis on five consumer products

2) Heuristic Evaluation

Heuristic evaluation is a usability testing method where evaluators carefully examine a variety of aspects of our software and judge the quality of key usability factors (Nielsen, 1995). We use this method to quickly identify major problems as well as successes. There are 10 main heuristic questions which cover almost all aspects of usability issues our software may occur and sub questions for each heuristic which evaluators would ask as they examined the software by finishing certain tasks. We recruited six landscape architecture students and one faculty to assess the software based on Nielson's 10 heuristic evaluation criteria (Table B2) in a group to go through three tasks like below:

1. In Philip and Chandler Park area, make a planting design in day time scene, using more than two different tree species, cost less than 600$
2. Add pavement, green infrastructure and terrain to the design in the night scene, using only two different tree species(which means you need to delete some), cost less than 1500$
3. Output the plan and data, find the folder contains the data

Category	Heuristic Question Category			
Feedback	Visibility of system status	Error prevention	Support Error Recovery	Provide Help
Understanding	Match between system and the real world	Aesthetic and minimalist design	Consistency and standards	
Action	User control and freedom	Recognition rather than recall	Flexibility and efficiency of use	

Table B2. Heuristic evaluation criteria

Heuristic	Brief description of the sub issue as it relates to the heuristic	Severity
1. Visibility of system status	Is it clear for users what area to edit?	3
	Does the system provide the progress 'Save'?	3
	Does the system provide the progress of 'FBX export'?	3
	Does the system let users know how to delete the road (right click)?	3
	Does the system provide the indication of manipulating terrain?	3
2. Match between system and the real world	Is cost/statistics graph provide information in comprehensible way?	3
3. User control and freedom	Can a user delete trees?	3
	Can a user edit terrain or move trees after placing?	3

4. Error prevention	Are warning messages are provided before user make a decision?	4
	Do error messages suggest the cause of the problem?	3
5. Flexibility and efficiency of use	Can a user flexibly adjust the generated path with the tool?	4
	Can a user easily delete bioretention?	3
	Does the system provide a function to reduce species number after putting?	3
	Does 'Load' button turns all objects without an error?	3
6. Provide help	Are instructions and tutorial provided when starting the software?	3
7. Support error recovery	Are instructions provided for each function during using the software?	3

Table B3. Selected heuristic issues (severity level 3-4)

3) Usability testing

In-person usability testing technique is based on user-centered design principle and its goal is to elicit beneficial information from users while they actually interacting with the software and help software development team to understand the users' expectations and needs. We recruited four urban design/planning practitioners who are working in a local urban design firm, SmithGroupJJR. Each test lasted about an hour in both exploratory and task-based manner. For the first 10 minutes, we asked participants to explore the software freely without any moderator guidance. After the exploration session, the participants performed three tasks for 10 minutes each: 1) site location, 2) object placement and following cost estimation, 3) terrain design and following cost estimation. We designed three tasks to be presented with a scenario to create a more realistic setting. After performing the tasks, we asked the participants to fill out a brief survey regarding the usability of the software and also we conducted semi-structured interview around their technology use and communication in urban design and planning process.

	Gender	Profession	Working Experience	Device	Familiar Software
P1	Male	Urban Planner	18 Years	Laptop	
P2	Female	Urban Planner	12 Years	Laptop	SketchUp, Illustrator
P3	Female	Landscape	4 Years	Paper/board and	SketchUp,

		Architect		pen, laptop, desktop	Lumion, AutoCAD, 3D Max, GIS
P4	Female	Landscape Architect	2 Years	Paper/board and pen, tablet, desktop	SketchUp, AutoCAD

Table B4. Usability Testing Participant Information

You and your landscape design company initiated a new public space design project in Philip Chandler Park, Detroit. You installed a new software projects architectural data as well as environmental cost data in the desktop and give it a try. Task 1 Your site is at the area around the intersection of Chandler Park Drive and Philip Street. You need to navigate to the area in the interface. Task 2 You want to make a simple planting design in the area and want to see what it will be like in day time. Additionally, it is required by client that you need to use more than two different tree species. The total cost of plants should be less than 2000$. Task 3 You want to add pavement, green infrastructure and terrain to the design. After adding those elements, you decided to reduce tree species to only two which means you need to delete some of them. The total cost need to be less than 10000$. Task 4 Export the FBX file of the scene and try relocate and open the file on the software again.

Table B5. Usability testing task Instructions for Participants

4) Community Resident Design Workshop

To deploy the tool in a for the real-world setting, we partnered with the Eastside Community Network in Detroit, MI and organized three sets of design workshops with residents. We recruited 15 participants, five of whom participated in all three workshops. Each workshop lasted 2.5 hours. The three workshops were structured as: 1) Actual site visiting and photo-taking activity, 2) the first Land.Info design session with the participant design priorities, 3) the second Land.Info design session with the client (Eastside Community Network) design priorities. For the design session, the participants worked with facilitators to design and plan the site of Mack Avenue in Detroit. At the end of the each design workshop, participants were asked to fill in an AttrakDiff questionnaire, which is widely leveraged in usability testing for software (Hassenzahl et al, 2004; Kukka et al., 2017).

Appendix 3. Redesigned Icon Sets

Simplistic, minimal icons can express and reduce user's mental burden to understand the functionalities of each icon. Icons should communicate the core idea and intent of a product in a simple, bold, and friendly way. From the heuristic evaluation and usability testing, the research team identified that some unfamiliar icons hindered and confused user interaction and eventually frustrate further interaction. Therefore, designers came up with a that is based on minimal style guideline.

Figure B3. Redesigned icons (Part)

Appendix 4. Stakeholder Contact Information

Dr. Mark Lindquist
School of Environment and Sustainability
440 Church Street
Ann Arbor, MI 48109-1041
734-763-8650

Kyle Bauer, Human Resources
SmithGroupJJR
201 Depot St., Second Floor
Ann Arbor, MI 48104
734-662-4457

Orlando Bailey, Richard Ackerman
Eastside Community Network
4401 Conner Street
Detroit, MI, 48215
313-571-2800