

PLACE PULSE MEASURING THE COLLABORATIVE IMAGE OF THE CITY

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B.S. Geographic Science
James Madison University, 2009

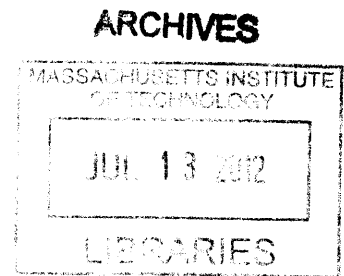
Submitted to the

**Program in Media Arts and Sciences,
School of Architecture and Planning,**

in Partial Fulfillment of the Requirements for the Degree of
Master of Science at the **Massachusetts Institute of Technology**

June 2012

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A handwritten signature in black ink, appearing to read "M. P. Salesses".

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ABSTRACT

This thesis presents Place Pulse, a tool capable of conducting large crowdsourced visual preference surveys. The data collected with Place Pulse was used to create quantitative measures of the perceptions people hold of urban environments. From this data, novel algorithms identified locations associated with positive and negative perceptions of safety, social class and uniqueness. The high throughput of the tool addressed two important methodological questions: the number of responses required to obtain robust results in a comparative study, and the number of images required to get a statistically significant evaluative map of a large city. In closing, the validated dataset was used to correlate perceptions of safety and social class to rates of both violent crime and high school graduation.

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PLACE PULSE MEASURING THE COLLABORATIVE IMAGE OF THE CITY

by **Phil Salesses**



Thesis Reader

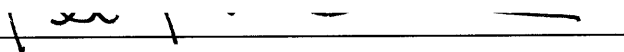
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ACKNOWLEDGMENTS

"I have no special talents. I am only passionately curious."

-Albert Einstein

My past two years at the Media Lab has been the most rewarding of my life. It has served as a wonderful platform for learning, personal growth and self discovery. I am forever indebted to the community at MIT and look forward to watching the ideas created during my time here take root in the world.

In particular, I would like to thank the following people:

César Hidalgo, my advisor, for mentoring me with grace and aplomb. As a new professor, his performance as an advisor, teacher and mentor exceeded any and all expectations I held. I look forward to growing with him over the next four years, hopefully improving society in radical way.

Katja Schechtner, my friend and mentor, for embracing my idiosyncrasies and for leading me along the yellow brick road by my ear. Through her grace, seemingly innocuous encounters often ended up blooming into spectacular outcomes.

Liz Tsai, my best friend, for helping me along my journey. I'll try an repay the favor next year when you go through the same.

Place Pulse development team: **Paul Sawaya, Michael Xu, Michael Wong, Kiran Bhattaram** and **Evan Marshall**. Without you all, this project would have still been a drawing on a piece of paper.

Place Pulse design team: **Anthony DeVincenzi** and **Professor Mauro Martino**. You two helped create a great exhibition at Ars Electronica and I'm happy to have worked with you both.

The Macro Connections group: **Alex Simoes** and **Shahar Ronen** for being great team mates, office mates and sounding boards for wacky ideas.

My thesis readers: **Sep Kamvar** and **Kent Larson** for reading my thesis. I value your input and I am grateful to have you both as readers.

My parents: **Laurie Salesses** and **Mark Salesses** for spawning and for providing me the tools I need to be a happy adult.

My siblings: **Tim Salesses** and **Jackie Salesses** for putting up with literally years of neglect while I go through school.

My friends: **Arthur Petron, Adam Setapen, Julia Ma, Andy Bardagjy, Dan Schulz** and **Anthony DeVincenzi**. You all are awesome and I can't wait to see where you all go in life.

David Gelvez for offering an amount of help that can only be described as "disproportionate."

Amanda Davis for her insights while designing the second version of Place Pulse.

My roommates: **Margaret Wang, Stefan Seer** and **Patrick Wolf**. Thanks for keeping me calm when I was busy and for holding down the fort when I would disappear for weeks at a time.

Others in no particular order: **Nate Mook, Dave Troy, Joi Ito, Vasco Grenadiero** and the late **Bill Mitchell** for all giving me a shot.

TABLE OF
CONTENTS

Introduction and Background	15
Approach	21
Methods	22
Experimental Setup	22
Original Contributions	26
High Throughput Tool to Measure Urban Perception	26
Place Pulse Dataset	27
Resolution Benchmarks	27
Implementation	28
Version One	29
Design	29
Development	30
Traffic Generation Strategies	33
Version Two	36
Design	36
Development	41
New Algorithms	42
Evaluation	43
Evaluation of Ranking Algorithm Robustness	43
Location Identification by Q-Score and Complex Criteria	45
Spatial Analysis	47

Correlation with Existing Datasets	55
Crime Rates	55
High School Graduation Rates	56
Conclusions	57
References	59
Appendices	64
Appendix A - Table of Known Visual Surveys and Scope	64

CHAPTER 1

INTRODUCTION AND BACKGROUND

“Everything has been thought of before, but the difficulty is to think of it again.”

-Johann Wolfgang von Goethe
German Writer

During the last three decades, research in behavioral psychology has demonstrated the ubiquity of unconscious processes in human action and behavior (Morsella, Bargh, and Gollwitzer 2009; Bargh and Morsella 2010). People are usually unaware of the sources of their behavioral impulses, which are many times imitative (Bargh and Chartrand 1999; Chartrand, Maddux, and Lakin 2005), driven by priming (Schacter 1992; Tulving and Schacter 1990) or by unconscious stereotypical responses to the environment (Morsella, Bargh, and Gollwitzer 2009; Bargh and Morsella 2010; Devine 1989).

A prime example of the social relevancy of stereotypical responses is the Broken Windows Theory (BWT) of Wilson and Kelling (Kelling and Wilson 1982). The BWT suggests that environmental disorder, such as

broken windows, litter and graffiti induce other kinds of disorder, like crime.

The BWT has been influential in criminology and has been cited as a justification for New York City's quality-of-life initiative (Bratton and Kelling 2006; Harcourt 1998), an order maintenance strategy that strictly enforces minor offenses, such as public drinking and turnstile jumping, in an attempt to prevent more substantial forms of crime, such as robbery.

In the past, the broken windows theory has been subject to debate (Harcourt 1998; Gau 2008; Pinker 2011; Keizer, Lindenberg, and Steg 2008). However, recent experiments by Keizer et al. (2008) have shown that visual evidence of disorderly behavior, such as graffiti (Figure 1-1) or supermarket carts left unattended in parking garages, are associated with an increase in the probability of people breaking other social norms, such as littering or stealing.

Figure 1-1
An image of graffiti
shown in Keizer et al.
(2008).



The consistency of Keizer's (2008) six experiments suggests that in specific situations, people's actions tend to be more influenced by injunctive norms (what people perceive as the common behavior of others) than by descriptive norms (prescriptions of what people ought to do in a specific situation). Although far from a full explanation of human behavior, the evidence in favor of the BWT demonstrates the

existence of a link between an individual's perception of the environment and his or her actions.

Beyond crime, the broken windows theory has been extended to public health, where associations between neighborhood disorder and health outcomes have been explored (Branas et al. 2011). In 2000, Cohen and Kissinger showed that cases of gonorrhea in New Orleans (Figure 1-2) correlated more strongly with an index of neighborhood disorder than with an index of neighborhood poverty.

Figure 1-2
New Orleans, LA was
the site of a 2000
study by Cohen and
Kissinger.

Photo courtesy of
Shubert Ciencia.



In the state of Illinois, Ross and Mirowsky (2001) showed that residents of disadvantaged neighborhoods, where noise, graffiti and vandalism are more common, have worse health outcomes than residents of advantaged neighborhoods, even after controlling for individual level disadvantages.

Evolutionary theory can help explain why our environment is likely to affect our behavior. When an organism recognizes signs of a threat, unconscious emotions, actions and perceptions allow that organism to quickly respond without performing computationally expensive considerations (Pinker 2003; Dawkins 2006). This is an example of what the philosopher Daniel Dennet calls evolution's shortcuts or "good

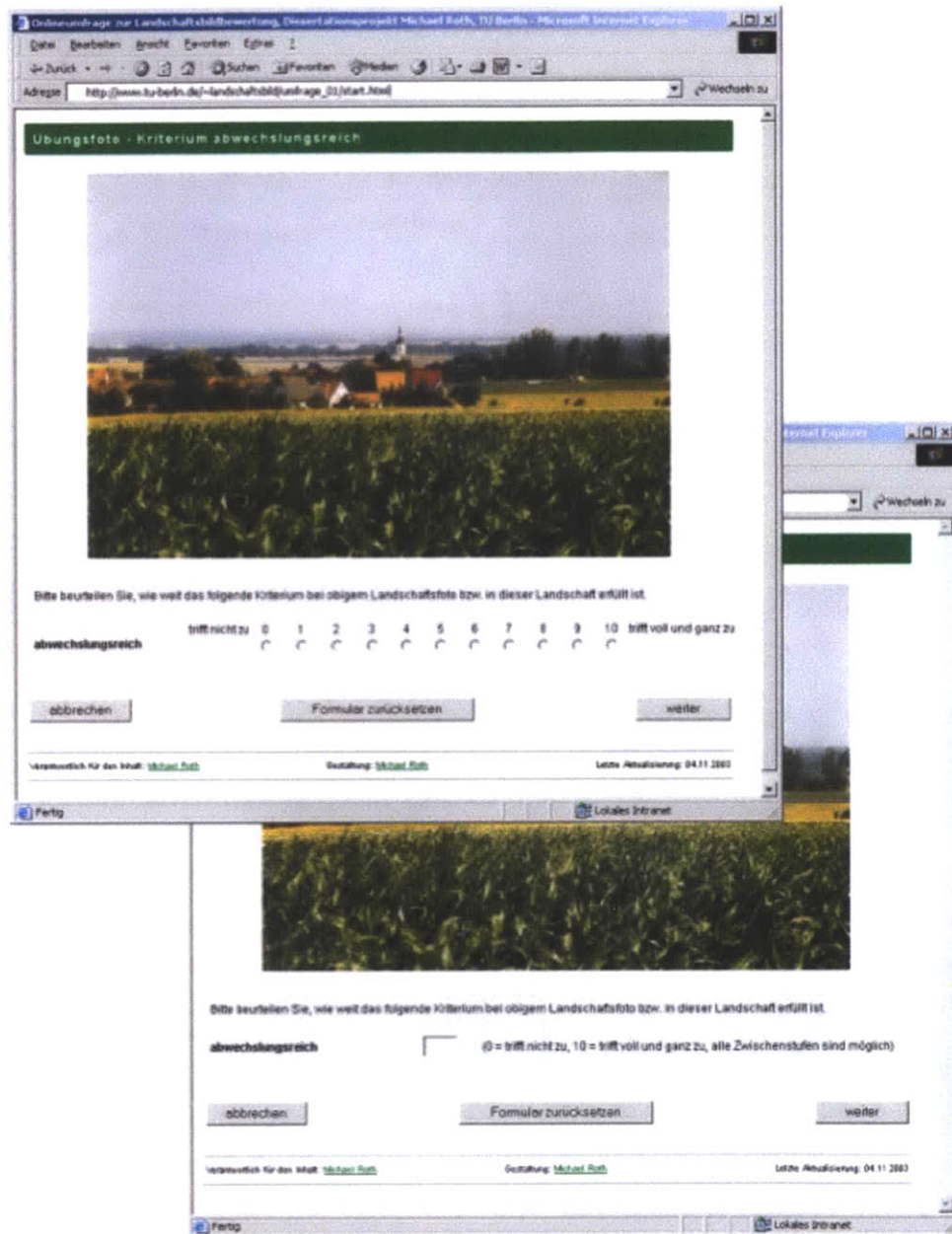
tricks" (Dennett 1996); chief among these tricks is our inclination to unconsciously imitate the behavior of others (Dawkins 2006).

Taken together, these studies demonstrate that the physical attributes of a neighborhood can significantly affect both behavior and health. Additionally, as the literature on cognitive and evolutionary psychology shows, these perceptions do not need to be mediated through conscious channels, since evolution could have honed these behaviors.

The desire to measure urban perception is not new. In the past, architects and urban planners have used visual survey methods, in which people rate images of urban environments, to identify features and emotions associated with a city's physical attributes (Peterson 1967; Nasar 1997; Nasar 1984; Milgram 1976; Herzog, Kaplan, and Kaplan 1976; Roth 2005; Wherrett 1999). Visual surveys are necessary to extract accurate urban perceptions. This is because many urban features, such as the neatness of a neighborhood, or the exterior beauty of its architecture, are not sold on the market, and therefore, urban perceptions cannot be inferred from existing mechanisms, such as price (R. L. Wilson 1962; Stuart and Weiss 1966). Visual preference surveys have also been used to contrast the aesthetic preferences of architects with those of citizens (Devlin and Nasar 1989; Nasar and Kang 1999), to identify neighborhoods that are more likable (Nasar 1997) and to identify features that affect a city's likability (Nasar 1984; Herzog, Kaplan, and Kaplan 1976; Nasar 1997).

Moreover, in the last decade, the internet has been validated as a survey medium to collect visual preference data (Figure 1-3) (Roth 2005; Wherrett 2010). Still, even the most recent online studies have been characterized by very low throughput, having tens or hundreds of respondents usually evaluating tens or hundreds of images (Appendix A).

Figure 1-3
Two different versions
of the online ques-
tionnaire used to
gather the participants
ratings (Roth 2005).



As a result, there exists no high-resolution multi-city dataset of urban perceptions that can be used, as a quantitative benchmark of a city's physical attributes, in large scale studies looking to understand the effect on urban perception on human behavior and social outcomes.

To overcome this lack of data and analysis, this thesis presents Place Pulse, a tool capable of conducting large crowdsourced visual preference surveys. The data collected with Place Pulse was used to create quantitative measures of the perceptions people hold of urban

environments. From this data, novel algorithms identified locations associated with positive and negative perceptions of safety, social class and uniqueness. The high throughput of the tool addressed two important methodological questions: the number of responses required to obtain robust results in a comparative study, and the number of images required to generate a statistically significant evaluative map of a large city. In closing, the validated dataset was used to correlate perceptions of safety and social class to rates of both violent crime and high school graduation.

This thesis is organized as follows:

Chapter two will focus on how this problem is approached and will cover methods for measuring urban perception, an experimental setup and the original contributions made. Chapter three covers implementation and strategies with which participants were located. The output from the experiment is examined and evaluated in chapter four. Chapter five wraps up the thesis with conclusions based on analysis. Finally, chapter six contains references and is followed by appendices.

CHAPTER 2

APPROACH

"A problem well-defined is half solved."

-Charles F. Kettering
Inventor

Since the effects of the environment on crime and health have been shown, there is a growing need for tools that can be used to measure a city's physical attributes, in high-resolution and across a variety of dimensions. (Roth 2005). For example, the physical attributes of urban environments could be linked to important dimensions beyond those of health and crime, such as economic growth, creativity (Bettencourt et al. 2007) or political participation. Moreover, high throughput data could help generalize experimental results to different geographies and high-resolution data could be used to compare cities or to identify the "thousands of broken windows" that exist in each one of them.

Methods

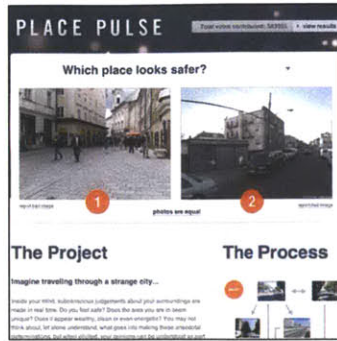
The method adopted for measuring urban perceptions was a computer-based approach that utilized an internet website instead of the traditional paper based questionnaires. Using the internet for visual surveys has been explored in the past (Wherrett 2000; Roth 2005) and has been used to varying degrees of success (Appendix A). However, instead of asking users to rate an urban scene using a number scale (Wherrett 2010), our method simply asks a participant to pick an image that seems more or less like a perception. For example, when users are shown two images and asked the question “Which place looks safer?” only three answers are considered acceptable: picking either image or an option to declare both images as perceptually equal.

This binary method of extracting preferences relies heavily on the number of observations collected to tease out which images are more or less like a perception. As an example, if a hypothetical dataset consisted of only two images and a million votes, the image perceived as “most like a perception” would simply be the image that was picked by survey participants more often. This approach becomes more difficult to implement effectively at scale due to other factors such as transitivity of votes or the images with which other images are paired.

Experimental Setup

To implement visual surveys at scale, we developed Place Pulse, a website designed specifically to crowdsource these surveys (Figure 2-1). Place Pulse sources its images primarily from Google Street View (GSV), an online imagery service with near global street level coverage.

Figure 2-1
The original version of the Place Pulse website.

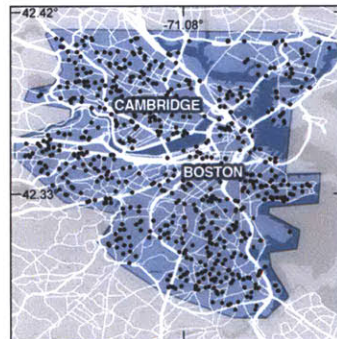


GSV's relatively standardized image quality throughout the world also provides a good platform for imagery. Additionally, Place Pulse can use JPEGs of manually collected imagery if users prefer more control over their visual surveys.

For the first experimental prototype of Place Pulse, version one, GSV images for Boston and New York City (NYC) were selected from locations randomly generated within a hand-drawn boundary (Figures 2-2 and 2-3). At each location, two images facing opposite directions were chosen as a way to measure the perception variation that exists within a location (Weimar 2008).

To increase robustness of version one, imagery capable of contrasting both the method of collection and substance of GSV imagery was required. The Austrian cities of Vienna, Salzburg and Linz were chosen to address both issues and images from these three European cities

Figure 2-2
The hand drawn boundary polygon for Boston and Cambridge, MA.



were collected manually on site using an iPhone 4. Locations were selected and photographed based on availability of access, time onsite and weather.

Figure 2-3
The hand drawn boundary polygon for New York City, NY.



Imagery from all five cities (Boston, New York City, Vienna, Salzburg and Linz) were manually curated to remove inapt images, such as those taken inside tunnels or those having large portions of a scene occluded by various obstructions. Approved images displayed approximately 75% of one side of a street and 25% of the other. This balance allowed elements in both the foreground and background to be seen in a single image.

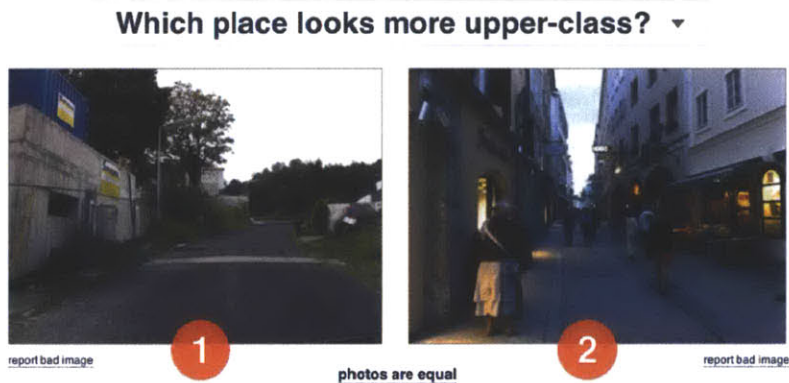
After curation, all approved images were included in three visual survey studies and presented to Place Pulse visitors. Upon visiting the site, users were shown two random images and asked to respond, by clicking an image, to one of the following three questions: "Which place looks

safer?" (Figure 2-4), "Which place looks more upper-class?" (Figure 2-5) or "Which place looks more unique?" (Figure 2-6). When responding to surveys, users were additionally provided the option to declare both images as perceptually equal for a given question. After responding to visual surveys by clicking an image denoting their choice, user's votes, and therefore preferences, were transmitted to the Place Pulse server and were recorded in a database as a directed link, pointing from the "winning" (clicked) image to the "losing" (unclicked) image.

Figure 2-4
Two images posed to users with the question "Which place looks safer?"

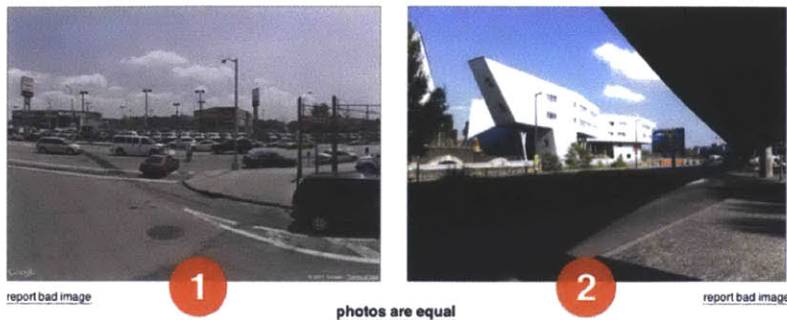


Figure 2-5
Two images posed to users with the question "Which place looks more upper-class?"



Which place looks more unique? ▾

Figure 2-6
Two images posed to users with the question “Which place looks more unique?”



Between August 1, 2011 and May 1, 2012, Place Pulse generated a dataset consisting of 4,740 images from five cities: New York City (1,705) and Boston (1,237) in the United States; and Vienna (604), Salzburg (544) and Linz (650) in Austria. The preference dataset consists of 584,924 votes cast by 19,869 people from 115 countries and covers three perceptions (safety, social class and uniqueness). To ensure a static dataset for all analysis, a subset of this dataset is used for the analysis in this thesis and was collected online from October 3 to October 27, 2011, a period when 7,872 unique participants from 91 countries contributed a total of 208,738 votes. Just as its superset, the subset also contains 4,740 images from the same five cities.

After collecting preferences using Place Pulse, the database of votes was used to rank each image according to a corrected win ratio (Q). The Q -score for each image was determined by its win ratio (the fraction of times the image was selected) corrected by the win and loss ratios of all images with which it was compared. This allows scores to adjust for the "strength of schedule" (Park and Newman 2005) of each image. If an image i is only compared with other images having high Q -scores, image i would have a "strong schedule." If image i happened to be chosen over an image with a high strength of schedule, that win would be weighted more heavily than wins over images with "weak schedules."

Image win (W) and loss (L) ratios are defined as:

$$W = \frac{w}{w+l+t} \quad (1)$$

$$L = \frac{l}{w+l+t} \quad (2)$$

where w is the number of events when an image is chosen over its paired image, l is the number of events when an image is not chosen over its paired image, t is the number of events when an image is chosen as equal to its paired image and:

$$Q_i = W_i + \frac{1}{n_i^w} \sum_j W_j - \frac{1}{n_i^l} \sum_j L_j \quad (3)$$

where i is an image to be ranked, j is an image compared to i , n_i^w is equal to the total number of images i beat and n_i^l is equal to the total number of images to which i lost.

Finally, Q is normalized to fit the range 0 to 10, where 10 represents the highest possible score for a given question. As an example, if an image receives a calculated score of 0 for the question “Which place looks safer?” that means that specific image is perceived as the least safe image in the dataset.

Original Contributions

This thesis provides three original contributions:

1. High Throughput Tool to Measure Urban Perception

Place Pulse is an online tool that makes it easy for anyone with an internet connection to measure urban perception at scale. The resulting data collected with the tool can be used to help understand human perception with regard to age, gender or cultural background and can help fulfill basic human curiosities about public perception. Further, the produced data can help improve the urban design process further by providing high-resolution perception data directly to those who can affect change. Moreover, the data could also be used by local governments to identify features that need improvement and to test potential changes before spending money on implementation.

2. Place Pulse Dataset

The Place Pulse dataset is the first large scale urban perception dataset and consists of 4,740 images from five cities collected online from August 1, 2011 to May 1, 2012. During this period 584,924 votes were cast by 19,869 people in 115 countries covering three perceptions (safety, social class and uniqueness). The Place Pulse dataset will be open sourced, allowing anyone to further contribute to this area of research.

3. Resolution Benchmarks

Finally, this thesis presents novel algorithms to determine the necessary number of images and votes required for a specific dataset resolution. This is useful to anyone wishing to expand on the work done in this thesis or to understand why certain design decisions were made.

CHAPTER 3

IMPLEMENTATION

“Never doubt that a small group of thoughtful, committed people can change the world. Indeed, it is the only thing that ever has.”

-Margaret Mead
Cultural Anthropologist

The first version of Place Pulse started with the creation of a simple data collection tool for research purposes. This was done by designing and developing a website to crowdsource visual surveys. The resulting data was computed and turned into the quantitative scores needed to analyze urban perception on a large scale. After this was completed, a second version of Place Pulse was started, incorporating lessons learned with the goal of making this technology available to the public.

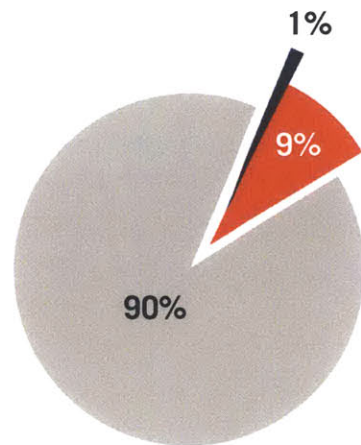
Version One

The original Place Pulse website was conceived and designed in a team effort with Anthony DeVincenzi under the guidance of Katja Schechtner and César Hidalgo beginning in July 2011.

Design

In keeping with software engineering best practices, it was first deemed prudent to identify all project constraints so the negative effects of which could be addressed with design. Two major constraints were identified. First, it was determined that directing a large number of survey takers to the Place Pulse website would prove to be a difficult task. For the project to have anywhere near the number of votes needed for scientific validity, it was estimated that at least 1,000 visitors would be required to generate every 100,000 votes, assuming every visitor voted 100 times and 100% of visitors participated.

Figure 3-1
*The Internet 1% Rule:
90% of users lurk,
9% participate and
1% contribute.*



Based on a well known internet rule (Arthur 2006), called the 1% rule, it was known that only 1% of website visitors contribute to a site in a meaningful way (Figure 3-1).

Therefore, the estimate for the required number of users was increased to 100,000.

This adjusted estimate seemed like a very high amount of traffic to attract to a research survey (Appendix A). Realizing no design could “fix” low traffic, we instead focused design efforts on increasing the user participation rate. We realized that every time the contribution rate could be doubled, the amount of traffic needed would decrease by half. Thus, improving the participation rate from 1% to 10% would mean an order of magnitude less users would be needed.

Another constraint was Google and their Terms of Service. Since Google requires all Street View imagery to be loaded through their

Javascript API, loading several images on a page meant loading several Javascript objects, an action that rapidly diminished browser responsiveness. After some initial tests, we limited the number of images that could be included on any one page to four, to ensure fast load time.

With the above constraints in mind, the main area of the website was created. All area above the scroll was dedicated to collecting votes from visitors. To make it easy for anybody to contribute, no personal data was initially requested from users. Instead, users were shown only a large question and two images (i.e. a visual survey). A straightforward user experience was also deemed critical for a high rate of user participation (Tidwell 2005), so no user accounts were required to participate either.

Although accounts were not necessary for participation, demographic data was still a desired addition for the Place Pulse dataset. Without it, many questions regarding age, sex or cultural background could not be linked to urban perception. Our solution was to present users, after five votes, a prompt asking them to self report age and gender. The prompt wording asked users nicely if they would be willing to provide two small pieces of personal information for the benefit of science. If a user indicated they they were not interested in providing the data, by closing the prompt, a second prompt immediately appeared asking them to reconsider. Although this approach is considered unfriendly design , we decided that the risk of turning a potential repeat user away was worth the rewards, given how valuable the information was to the study and how quickly and easily it could have been provided by the user.

Development

A seamless user experience is often difficult to program. As user interfaces should be smooth and experiences seamless (Tidwell 2005), many things had to be juggled behind the scenes to ensure no information was lost. It can be especially difficult to accomplish this when working with closed APIs and systems, like that of Google's Street View.

The Google Street View API turned out to be both the project's foundation and its weakest link. Since images were loaded using Javascript objects, the user interface often became unresponsive, even when only loading two images on a page. The way the surveys were initially programmed meant that after a user clicked an image to vote, the page would immediately request two new images from Google behind the scenes. Loading those new images often took several seconds and made the website appear slow.

As a solution, a buffer was implemented to improve responsiveness. With this new approach, when a page was initially loaded, it would request four images, instead of two. Two were displayed immediately to users just as before, only this time, the other two images were stored in a cache and not shown on the page. This meant that when a user clicked an image to vote, new pairs of images were instantly loaded simply by making the cached images "visible." Loading the next two images still took several seconds, but that process occurred in the background while the user was thinking about how to answer the visual survey. This new approach limited the time users had to consider leaving the site before new pairs were shown and the resulting experience was described by one twitter user in a personal message as "addicting."

For all development we used a hardware setup consisting of an Apple Mac Pro with 32GB RAM and 4 hard drives configured in RAID 5.

SOFTWARE BACK END

Since Apache is installed on all Apple hardware by default, it was chosen to reduce complexity. By using standard hardware and software configurations, Place Pulse can be more easily run by users, once open sourced. In addition, limiting setup complexity results in faster development .

PHP was picked as the primary programming language due to the team's past familiarity with it and its ability to meet all functional requirements. CodeIgniter was used as a light PHP framework allowing for rapid development through the use of a loosely implemented Model, View Controller (MVC) design pattern. This made CodeIgniter incredibly flexible and easy to use. The downside to using CodeIgniter

was that once the project reached a certain size, maintaining the code became time consuming. As Place Pulse hit that development wall, an additional component, Bonfire, was deployed to help manage code.

Bonfire extends CodeIgniter's MVC design pattern by allowing hierarchical development. Bonfire's added Hierarchical MVC (HMVC) enabled modular development and was beneficial for several reasons. First, it allowed many people to work on separate parts of the project without causing conflicts in code. Second, it allowed the code to be maintained in a more organized manner, letting team members program modules that easily plugged into the larger site. Although the convenience of HMVC produced a noticeable performance hit when generating pages dynamically, most pages were to be served from cache, negating rendering time as a drawback.

SOFTWARE FRONT END

Developing the front end of Place Pulse required a fair number of server queries to occur without reloading the page. jQuery was used because of its ability to easily handle asynchronous server communication through AJAX and its ability to decode any returned JSON easily with built-in functions. jQuery powered client-side form validation and the survey voting engine. A jQuery script was written to detect and intercept clicks from users while voting and alter elements on the page. The main example of this was making the cached Street View visible after a user had voted.

Google Street View does not allow the exact location of a panorama to be known beforehand since it doesn't expose its coverage layer. This meant that finding Street View images was a computerized version of guess and check. After a polygon was defined using a custom script, algorithms would guess points randomly within that polygon and query Google for Street View data. If data was returned within 50 meters of a guessed point, the latitude and longitude of the guess was saved in the database for later retrieval. Guessing points to populate the database was handled in a special administration section of the site. After points were stored in the database, locations could be displayed to users by randomly selecting a few rows of data and requesting the images from Google.

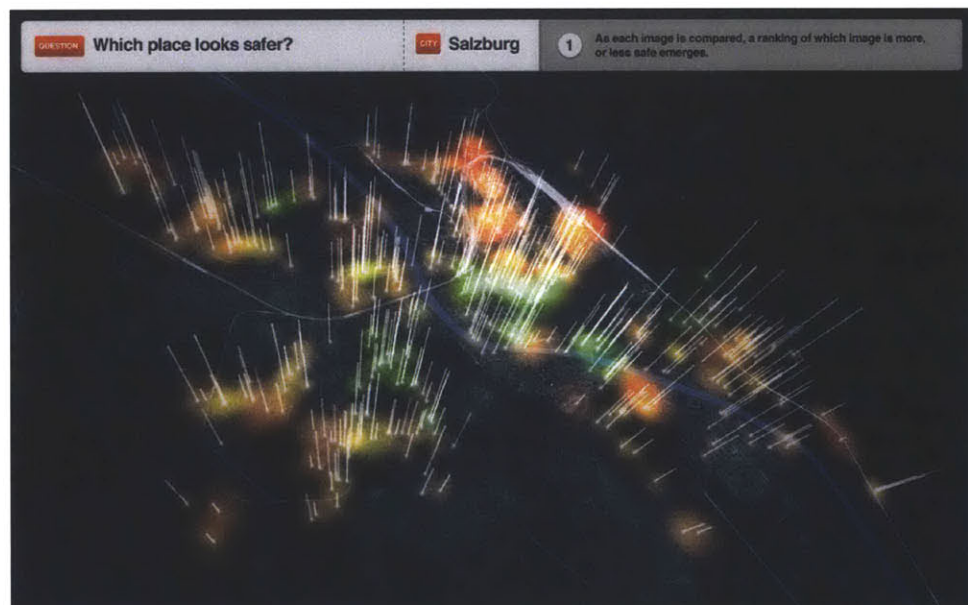
Traffic Generation Strategies

As generating a large amount of traffic was crucial for the project, a significant amount of thought went into how to find new users. Using the internet as a marketing machine meant entering an over-saturated market, where all walks of life were searching for attention; standing out would be decidedly hard. The way musical bands promote themselves was used as an informal case study. Looking to grow their name recognition, bands often go on tour, playing anywhere people will listen. We adopted that strategy for Place Pulse as a way to build clout and solicited several venues for openings. Any offers to talk or demonstrate Place Pulse were accepted.

PUBLIC EXHIBITIONS

Place Pulse was exhibited at the 2011 Ars Electronica Festival in Linz, Austria. Ars Electronica is the world's largest festival of digital media art and design. In preparation for the festival, Anthony DeVincenzi, Mauro Martino, César Hidalgo and I collaborated over several months to design an interactive exhibition for the project that would convey the purpose, data and results in an appealing way.

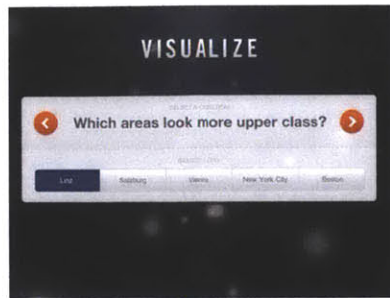
Figure 3-2
A screenshot of the Ars Electronica visualization for the city of Salzburg, Vienna displaying results for the question "Which place looks safer?" Green corresponds to areas of relative perception of safety while red represents the opposite. The height of the bar displays how many votes were collected for each location.



The finished installation itself was quite simple. A projector was used to display a visualization (Figure 3-2) while two iPads were stationed in

Figure 3-3

The iPad that allows patrons to control the visualization in figure 3-2. Questions could be changed using the red arrows and the cities by touching a button.



front for user interaction. Users were able to control the projection and the visualization displayed by interacting with one of the iPads (Figure 3-3). This iPad could switch between questions and cities and would update the visualization in real time.

Users could also contribute to the project by interacting with a second iPad (Figure 3-4), designed to collect votes and relay them back to the main Place Pulse server.

Figure 3-4

The iPad that allows patrons to control the visualization in figure 3-2. Questions could be changed using the red arrows and the cities by touching a button.



Visualizations, an example of one shown in Figure 3-2, were created in collaboration with Anthony DeVincenzi and programmed by Dr. Mauro Martino from the Northeastern University Center for Complex Network Research. Processing was chosen as the graphics

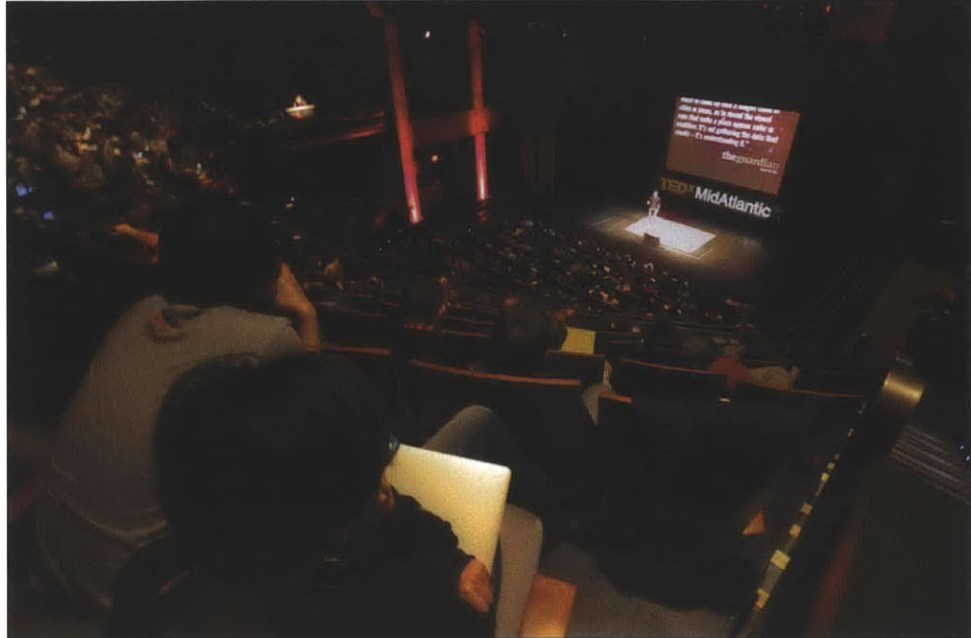
library and run on a computer attached to the projector. The visualizations ran inside a custom developed application, designed for specific exhibition constraints.

The exhibit at Ars Electronica was well received, resulting in a total of 5,340 votes being collected over the two months of the installation. A much larger indirect benefit, however, was the amount of press coverage that was generated from our presence in Austria.

In addition to Ars Electronica, several demonstrations and talks were given in the months after. The largest two, TEDxMidAtlantic saw Place Pulse pitched to a crowd of 1,000 (Figure 3-5) and another 500 at TEDxCambridge. None of those appearances resulted in any significant traffic, but instead created indirect buzz.

Figure 3-5
 Phil Salesses demonstrating Place Pulse to a crowd of over 1,000 at TEDxMidAtlantic in Washington, DC.

Photo courtesy of Timothy Forbes.



MEDIA COVERAGE

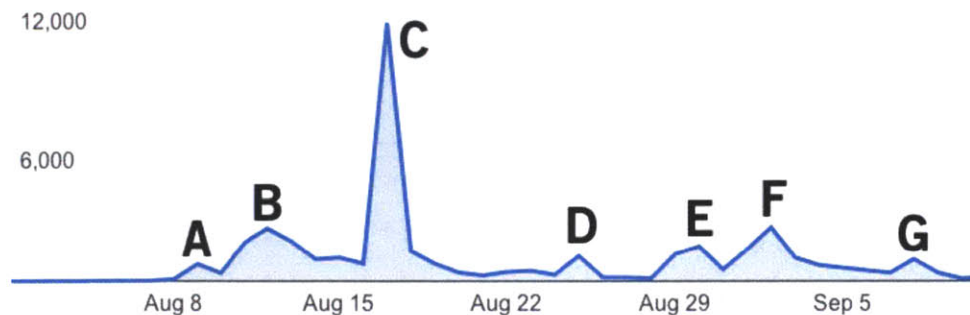
Before Ars Electronica, Place Pulse was submitted to Twitter, Facebook and Google Plus with the hopes of generating votes. On August 8, 2011, Place Pulse was sent to friends of the team on Twitter (Figure 3-6), Facebook and Google Plus, resulting in a one-day initial traffic spike of 738 visits (Figure 3-7 A).

Figure 3-6
 A tweet from former Apple evangelist, Guy Kawasaki.



The traffic died down by August 10th and a second push was made, this time through Reddit and Digg, two social news aggregators. Reddit and Digg were responsible for a spike of 2,277 visits (Figure 3-7 B).

Figure 3-7
 Traffic spikes and corresponding media coverage.



Spikes A and B alone generated greater than 100,000 votes, far

beyond expectations and it was decided that efforts to generate traffic should be paused while work on analyzing the results began. However, on August 17, the gadget blog Gizmodo (Hannaford 2011) picked up the story (Figure 3-7 C) and created a one day spike of about 11,000 visits, bringing in an additional 200,000 votes.

Two days later, the Guardian newspaper (Rose 2011) ran an article on Place Pulse, prominently displayed in their art and culture section, but did not generate any significant traffic. The remaining spikes corresponded to articles written about Place Pulse in tech news site Technowinki (Figure 3-7 D), Fast Company Design (Labarre 2011) (Figure 3-7 E) and MicroSiervos (Alvy 2012) (Figure 3-7 F). Residual social network traffic was responsible for the final spike on Sept 8 (Figure 3-7 G).

Version Two

After traffic on the extremely popular first version of Place Pulse had simmered down, a second version was started, incorporating lessons learned from version one. The goal of this second version was to produce a website where anybody could create and crowdsource their own urban perception study.

A team was assembled, consisting of some familiar faces and many new ones. Lending a hand to help develop the new site was Paul Sawaya, Michael Xu and Michael Wong. Planning was helped by Anthony DeVincenzi and Amanda Davis while advisement was again provided by Katja Schechtner and César Hidalgo.

Design

The design of the new site was similar to that of version one. Keeping it simple and inviting stayed central to the design process. Place Pulse version two (Figure 3-8) was designed in a browser using Twitter's Bootstrap, a front end framework specifically touted for its rapid development capabilities. Bootstrap was especially useful for preventing compatibility issues normally found when using libraries cobbled together from various sources.

Figure 3-8
Place Pulse version two, displaying a study created by a user.



CREATE A STUDY

The central component in the second version of Place Pulse was the ability for users to create their own studies. To do that, a user would click the “Create a Study” link in the menu at the top of every page.

A wizard-like page (Figure 3-9) then guided users through the process of creating a study, prompting them to name their study, choose a question to ask users and decide whether the study would be open to the public or not.

Figure 3-9
Creating a study in version two of Place Pulse takes 5 steps.

STEPS TO CREATING A STUDY

- Study Information
- Select Places
- Populate Locations
- Curate Images
- Start Collecting Votes

Step 1 of 5:
To get started, please share some basic information with us.

Study Information

Study Name

Question to Ask Users Which place looks more ?

Open to the public? Yes No
If “No” is selected, you will have to provide your own study participants by sending them a link.

If a study was set to private, users had to provide all traffic for that study by sending out a link to participants. The ability to mark a study

as private could be beneficial if a representative survey sample was needed.

After providing the information requested, users were taken to a second page (Figure 3-10) where they are asked to select an area they wished to study.

Figure 3-10
Creating the study area polygon and some metadata.

STEPS TO CREATING A STUDY

- Study Information
- Select Places**
- Populate Locations
- Curate Images
- Start Collecting Votes


Step 2 of 5:
Now, select an area you want to study by drawing polygon on the map. To start, click any three places on the map.

Where do you want to source your images?

Google Street View Upload Your Own From Existing Study

Define Area

Select Image Search Area by clicking three places on the map to create a polygon.



Clear current selection

Place Name

Generate Locations When selecting locations within your polygon, this is the method we will use.

Location Resolution This will help us determine the density of locations within your polygon.

Using an embedded map, users could easily define a polygon around any area in the world, simply by clicking where they wanted to place polygon vertices. At the start, users were prompted to click in any three locations to form a triangle. In response to where a user clicked, green markers were added to the map, allowing users to easily see what would be included in their selection. Moving a marker was possible by clicking and dragging it and markers could be removed by clicking on it once. If a user happened to define a polygon that was too large (area > 500 miles), the polygon turned red and users were prompted to reduce the square mileage encompassed by their polygon.

A form field below the defined polygon requested some basic information that would help the following steps process the study. Options to control how locations were selected (randomly or randomly within a grid) and setting the resolution of resulting data was programmed Michael Xu. Controlling the distribution of generated points within the polygon is useful for various reasons but mostly depends on how the resulting data will be used. The output resolution was also important and allowed users to know the resolution of their study before it even began.

Pressing continue loaded a page that would populate locations (Figure 3-11) using the polygon and methods specified on the previous page. Points were asynchronously guessed within the polygon and if data was successfully returned by Google, that point was added to the database.

Figure 3-11
Populating the database by guessing and checking points.

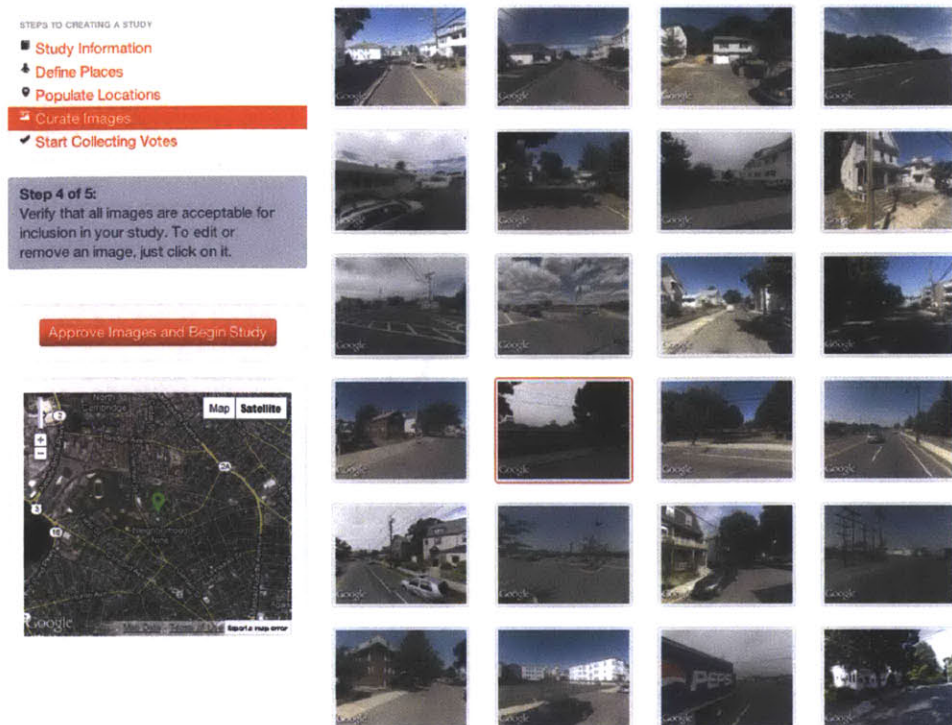


To keep a user engaged during this automated process, the screen displayed a progress bar and some eye candy, consisting go markers falling from the sky.

During this stage, if points were unsuccessfully returned under 20% of the time, possibly due to a lack of Street View coverage, users were redirected back to a prior page where they could adjust their polygon to include a new area.

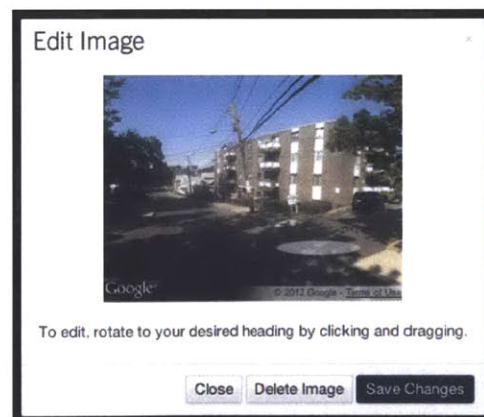
The final step in creating a study was to curate the images (Figure 3-12) found in the populate locations step.

Figure 3-12
Curating images is easy with a tool designed to help.



If users were in a hurry, they could allow the crowd to “report bad data” by clicking on a link shown below every survey image. For those that needed a little more accuracy in their study, each image that would be displayed to users was displayed as a thumbnail on the right. Hovering over the image would drop a pin on the map, allowing users to see where that specific point was located.

Figure 3-13
Edit or delete images in the curation step by using the popup.

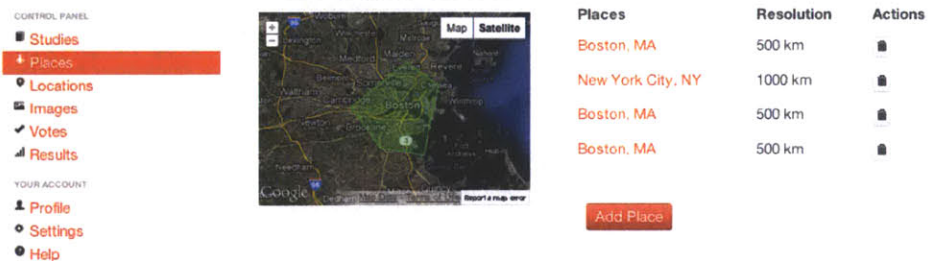


If an image was determined to be inappropriate for the study, for reasons of poor image quality or major occlusions, clicking on the thumbnail brought up a modal window (Figure 3-13) where an image could be altered by rotating the panorama or deleted. Clicking a save button would freeze the current panorama and update the view in the database. After, the modal was dismissed, users would then be returned to the curate screen to repeat the process until all images were verified.

Once the process of curating images had completed, users can click “Approve Images and Begin Study” which would then take them to a page where they were provided a link to their specific study. After approving images, the created study went live on the Place Pulse website, and was immediately presented to any users on the main page. It was also accessible through other pages where visitors can browse existing studies by city, question or popularity.

If something was forgotten or typed mistakenly during the study creation process, users always had the option to go back and edit anything through the control panel (Figure 3-14).

Figure 3-14
The control panel gives users control to alter existing studies.



Development

New capabilities always require new technologies and because of the new features the second version of Place Pulse called for, new technology was necessary to develop the site.

SOFTWARE BACK END

The first upgrade to the second version was the database, migrating from a relational MySQL database to a document based MongoDB. The benefits of using Mongo were many, including simplified queries and the ability to grow a table in dimensions prohibited by relational databases such as MySQL. Paul Sawaya, Michael Xu and Michael Wong helped create the new database schema and port existing data from the first version.

In addition to the database, PHP and CodeIgniter were abandoned in favor of Flask, a Python based framework, matching the existing skills of the team with the skills required for development.

SOFTWARE FRONT END

To reiterate, Twitter Bootstrap was used to redesign the site and offered many benefits. One such benefit was eliminating collisions between Javascript libraries. Often when developing for the web, libraries are used from various locations around the web. Sometimes when multiple libraries are loaded on a single page, conflicts can occur which are notoriously difficult to track down. Bootstrap eliminates this by including commonly used libraries in a single package. Twitter did a great job ensuring interoperability between libraries by creating an integrated “front end framework.”

For Bootstrap to function, jQuery was necessary so much of the old custom code from version one was able to be ported to the second version with little effort.

New Algorithms

In the first version of Place Pulse, images were provided to users after randomly selecting two locations from a database, an approach not particularly efficient when thousands of images exist within a single study. As an improvement, images in version two were selected based on a simple algorithm that pulls images based on their scores. Images with very high and very low Q-scores are never paired together since the outcome of that vote is highly predictable. Instead, images with similar Q-scores are compared and adjusted very with each vote. This ranking method and subsequent score “drift” is what allows the new ranking to algorithm to stabilize faster than if points were simply selected at random.

CHAPTER 4

EVALUATION

“One test result is worth a thousand expert opinions.”

-Wernher von Braun

German-American Rocket Scientist

Voting data used for experimentally validating the research question was collected online from October 3 to October 27, 2011, a period when 7,872 unique participants from 91 countries contributed a total of 208,738 votes. It consists of 4,740 images from five cities: New York City (NYC) (1,705) and Boston (1,237) in the United States; and Vienna (604), Salzburg (544) and Linz (650) in Austria. Images from NYC and Boston were sourced digitally from Google Street View while images from Vienna, Salzburg, and Linz were shot manually onsite.

Evaluation of Ranking Algorithm Robustness

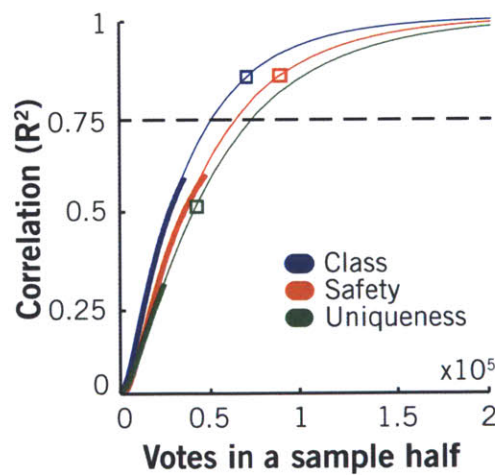
To verify the robustness of the ranking method, the number of votes required to obtain a stable set of Q-scores was calculated. This was

done by splitting the voting dataset 100 times into non-overlapping subsets containing v votes. Subsets containing up to 50% of the total votes are used because this is the largest value that still allows rankings to be calculated using subsets where there is absolutely no intersection. The measure of robustness B is the R^2 of the Pearson correlation between two subsets containing the same images and a ranking based on N different votes. A value of B equal to 1 would indicate a ranking that is perfectly robust to the set of votes used, as long as they are the same i_n number. Values of $B > 0.75$ are considered to be highly robust.

Figure 4-1 shows the average B obtained for subsets as a function of N (thick line). The thin line shows the fit:

$$B = \left(1 - e^{-\beta x^\alpha}\right)^2 \quad (4)$$

Figure 4-1
A graph showing the correlation between sample halves, used to measure robustness.



where α and β are fitting parameters. The high accuracy of the fits ($R^2 > 0.9969$ for safety, $R^2 > 0.9989$ for social class and $R^2 > 0.9991$ for uniqueness) allowed us to extrapolate and estimate the value of B given the number of votes v for each of the three questions. The 93,622 votes collected (red square) for the safety question resulted in B

$= 0.863$, meaning $B > 0.75$ when 67,003 votes had been collected. The 70,157 votes for social class (blue square) resulted in $B = 0.844$, meaning $B > 0.75$ when 52,996 had been collected. The least robust dataset was the one associated with the question of uniqueness, with 48,109 votes (green square) and $B = 0.560$, meaning 76,489 votes would have been needed to cross the robustness threshold.

Overall, the statistical behavior of the three questions is extremely similar, in part due to the high transitivity of the observed preferences (86.76% for safety, 87.00% for class and 83.34% for uniqueness). As

a simple rule of thumb, we find that between 11 and 16 votes are needed per image to produce a robust ranking ($B > 0.75$) but the actual value will depend on many factors such as how personal a perception is among survey participants, transitivity of votes, etc.

Location Identification by Q-Score and Complex Criteria

Typical images associated with high and low scores for safety (Figure 4-2), class (Figure 4-3) and uniqueness (Figure 4-4) are shown below.

Figure 4-2 (left)
Images with high and low scores for safety are shown.

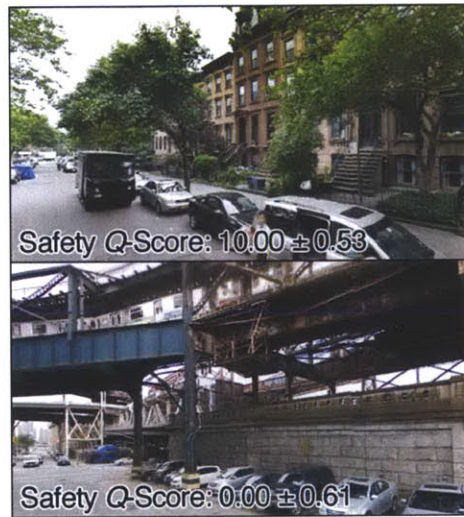


Figure 4-3 (right)
Images with high and low scores for social class are shown.



Figure 4-4
Images with high and low scores for uniqueness are shown.



As expected, places perceived as safe, are also more likely to be perceived as upper-class ($R^2 = 52.0\%$, $p\text{-value} < 0.0001$) and/or unique ($R^2 = 22.5\%$, $p\text{-value} < 0.0001$).

The extent of the data allows us to identify images matching particular combinations of criteria, such as images where the perception of safety matches that of class (Figure 4-5, I and III)

and where these two variables run opposite (Figure 4-5, II and IV).

Figures 4-6 and 4-7 repeat the analysis for safety and uniqueness and social class and uniqueness ($R^2 = 23.4\%$, $p\text{-value} < 0.0001$).

Figure 4-5
Scores for safety and class are plotted for all locations, allowing locations to be found by complex criteria.



Figure 4-6
Scores for safety and uniqueness are plotted for all locations, allowing locations to be found by complex criteria.

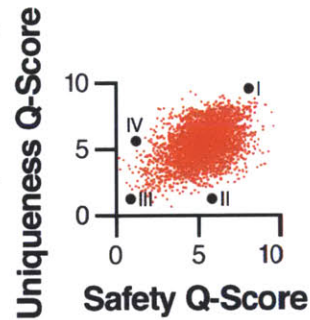
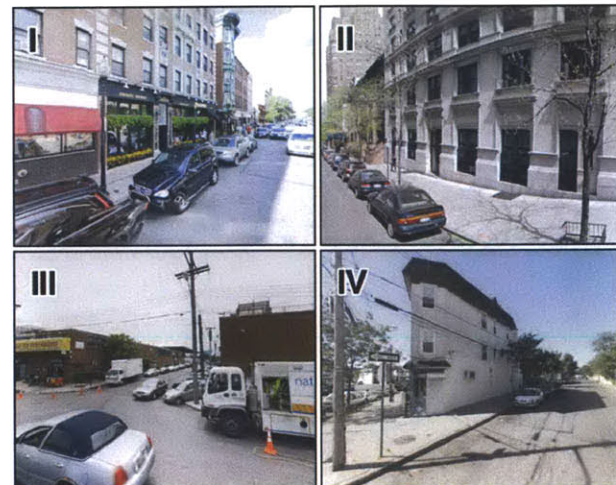
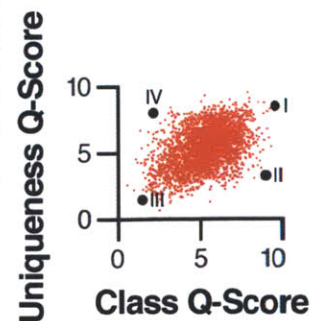


Figure 4-7
Scores for class and uniqueness are plotted for all locations, allowing locations to be found by complex criteria.



Together, these results show that data collected through this method can be used to identify images satisfying combinations of criteria that would have been harder to identify by asking a more direct question, such as "Which place looks more upper-class but not safer?"

Spatial Analysis

Next, we explored the spatial patterns present in the data. Since there are two images associated with each location for NYC and Boston, we begin by nudging each image's location (latitude and longitude) in our database by a distance of 1.11 cm, or 1×10^{-7} decimal degrees, towards the direction of its heading. This ensures that each observation is taken as a separate observation by the spatial analysis software.

Measures of spatial autocorrelation can help understand the level of spatial resolution required to create a statistically significant evaluative map. Moran's I is designed to measure the global spatial autocorrelation between a map's cells and figure out whether these have values that tend to be similar to that of their neighbors. A checkerboard pattern is associated with a value of $I=-1$, whereas a completely random pattern is associated with $I=0$. Perfect segregation, on the other hand, is associated with $I=1$. For all of the studied cities and questions we find a positive and significant values of Moran's I after translating them to Z-scores (Table 4-1). Z-scores greater than 1.96 or smaller than -1.96 indicate significant spatial autocorrelation at the 5% level. Table 4-1 indicates that images tend to have scores that are similar to that of their neighbors.

Table 4-1
Z-scores and p-values for analysis cities and questions asked in the Place Pulse dataset.

City	Question	Z-Score	P-Value
New York City	Safety	24.661	<0.001
New York City	Social Class	41.598	<0.001
New York City	Uniqueness	37.964	<0.001
Boston	Safety	14.772	<0.001
Boston	Social Class	13.856	<0.001

City	Question	Z-Score	P-Value
Boston	Uniqueness	6.757	<0.001

After spatial autocorrelation was confirmed, we mapped the raw perception data as a geographically clipped Voronoi diagram and colored the cells according to the geometric mean using ESRI's ArcMap software. This was done to determine the next analysis step and to see if any spatial patterns were visually apparent (Figures 4-8, 4-10, 4-12, 4-14, 4-16 and 4-18). After examining the raw perception maps for NYC and Boston, it was clear that there was a pattern, but further analysis was needed to draw it out clearly from the data.

To locate distinct areas where common perceptions exist, the Getis-Ord G_i^* statistic was used to find statistically significant clusters or "hot spots" of either high -or low- Q-scores. In the case of NYC, significant clusters of high Q-scores for all questions were present in Manhattan and Brooklyn Heights. Significant clusters of low Q-scores, on the other hand, were located in large parts of Queens and Brooklyn (Figures 4-9, 4-11 and 4-13). In Boston, low Q-scores clustered in Somerville and Everett, while high Q-scores were clustered in Brookline and surprisingly, Dorchester (Figures 4-15, 4-17 and 4-19).

Note: for both high and low Q-scores, p-value < 0.0001. The lack of significant clusters in other areas indicates that, at the level of spatial resolution observed, these neighborhoods are highly heterogeneous, with a more or less random intermixing of images associated with high -and low- Q-scores.

These results show that a complete evaluative map of NYC will require increasing the resolution in (gray) areas with Z-scores between -1.96 and 1.96. This corresponds to some Brooklyn neighborhoods, such as Borough Park, where the heterogeneity of the neighborhood is higher than the current spatial resolution. The homogeneity of Manhattan, on the other hand, would allow us to reduce the spatial resolution of the study, and hence, reduce the number of votes that we would need to collect while still generating significant results. Certainly, this is something that cannot be known prior to the study.

LEGEND for
Figures 4-8 to 4-19

Q-Scores by Geometric Interval

- Bottom 20%
- 20% - 40%
- 40% - 60%
- 60% - 80%
- Top 20%

GI* Z-Score (Standard Deviations)

- < -2.58
- -2.58 - -1.96
- -1.96 - -1.65
- -1.65 - 1.65
- 1.65 - 1.96
- 1.95 - 2.58
- > 2.58

Figure 4-8 (left)
"Which place looks safer?" NYC perception raw data..



Figure 4-9 (right)
"Which place looks safer?" NYC perception hot spots.



Figure 4-10 (left)
"Which place looks more upper-class?" NYC perception raw data.



Figure 4-11 (right)
"Which place looks more upper-class?" NYC perception hot spots.



Figure 4-12 (left)
"Which place looks more unique?" NYC perception raw data.



Figure 4-13 (right)
"Which place looks more more unique?" NYC perception hot spots.

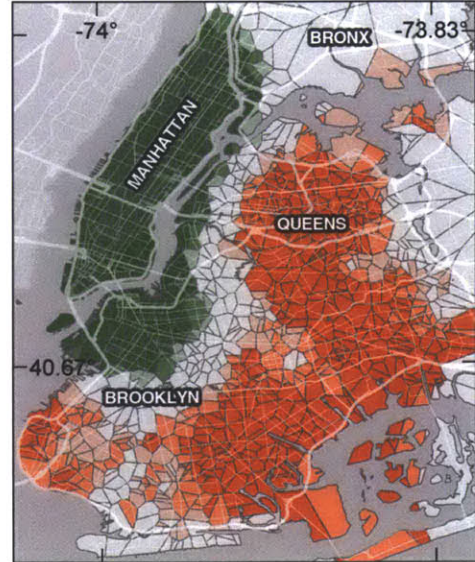


Figure 4-14 (left)
"Which place looks safer?" Boston perception raw data.

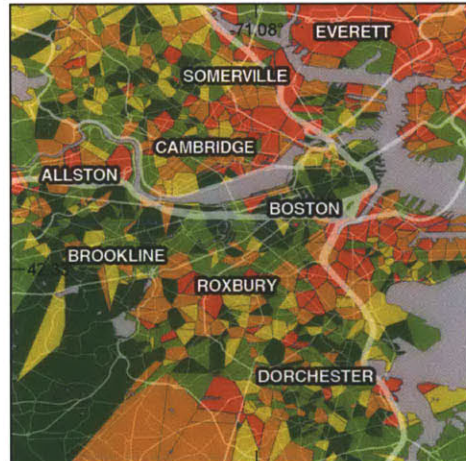


Figure 4-15 (right)
"Which place looks safer?" Boston perception hot spots.

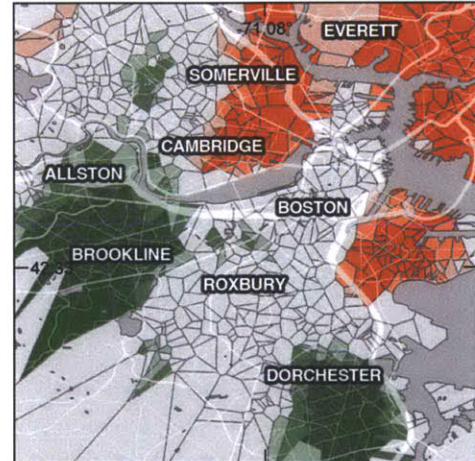


Figure 4-16 (left)
"Which place looks more upper-class?" Boston perception raw data.



Figure 4-17 (right)
"Which place looks more upper-class?" Boston perception hot spots.

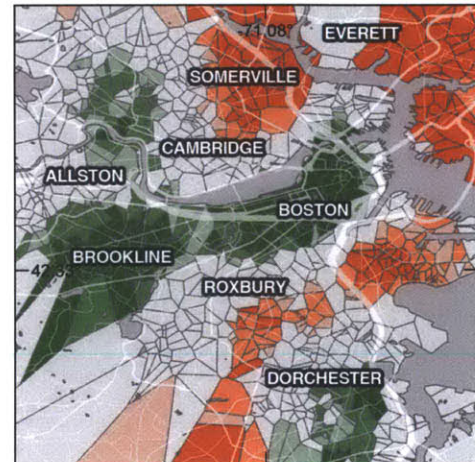


Figure 4-18 (left)
 “Which place looks more unique?” Boston perception raw data.

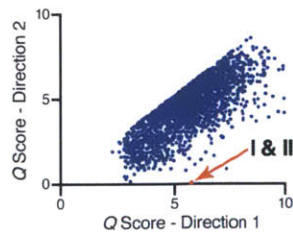


Figure 4-19 (right)
 “Which place looks more unique?” Boston perception hot spots.



Next, the Q-scores of images from the same location but with opposite headings were compared to see how much variation exists between two images at the same location. This was done in an attempt to find out how much a heading matters when walking down a street. Figure 4-20 shows a scatter plot for each pair of scores where the highest score is always used on the horizontal axis. This shows that, overall, the score of an image obtained in one heading is a decent predictor of the score of an image taken at the same location but with an opposite heading (safety: $R^2 = 0.596$, $p\text{-value} < 0.0001$, social class: $R^2 = 0.569$, $p\text{-value} < 0.0001$, uniqueness: $R^2 = 0.480$, $p\text{-value} < 0.0001$). The R^2 of this relationship is interpreted as the amount of the variance explained by the location and $1-R^2$ as the percentage of the variance associated with the heading. An outlier is high lighted in Figure 4-20 I and II, showing images at the same location that have Q-scores that are both high (Figure 4-20 I) and low (Figure 4-20 II).

Figure 4-20
 Q-scores for locations with two points for the question “Which place looks safer?”



To measure the effect of individual features, we looked at the difference of Q-score between an original image and a digitally modified version. Physical features that affect people's perception are identified by using digitally modified images from the Austrian cities of Vienna, Salzburg and Linz. The manually collected imagery are used

for this because the Google Street View Terms of Service do not allow for the digital modification of their imagery.

Figures 4-21, 4-22 and 4-23 show the original images and their digitally altered counterparts together with their respective Q-scores for each question. In total, 22 images were modified with each digital alteration changed one set of features. For example, in Figure 4-21, an image taken in the city of Linz (Figure 4-21 I) is compared with a modified version in which graffiti tags were added (Figure 4-21 II). Here, a statistically significant decrease is found in the Q-scores for safety (p-value = 0.0459) and social class questions (p-value = 0.0007), but not for uniqueness (p-value = 0.4193).

Figure 4-21
Figure shows a location in Linz before and after adding graffiti to the image.

* = Significant at 5%
** = Significant at 1%

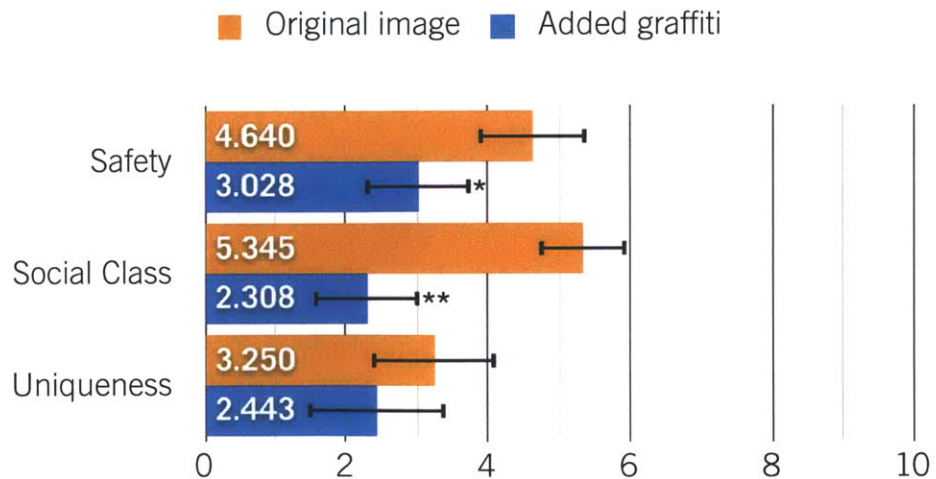
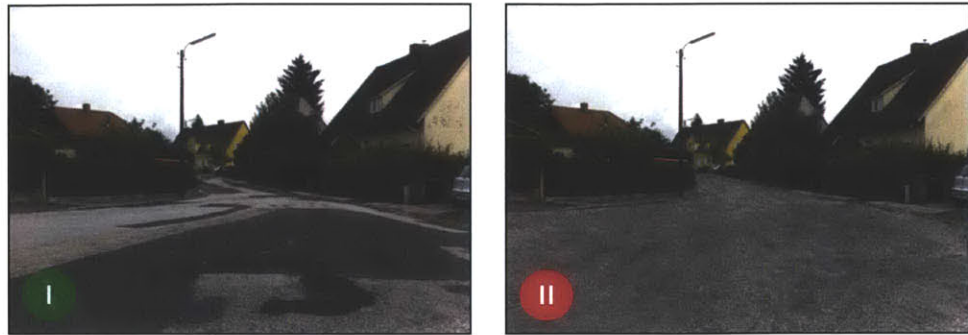


Figure 4-22 compares an image from the city of Salzburg (Figure 4-22 I) with one in which the pavement has been resurfaced (Figure 4-22 II). The analysis shows that here, the only statistically significant difference is in the perception of social class (p-value = 0.0120), but

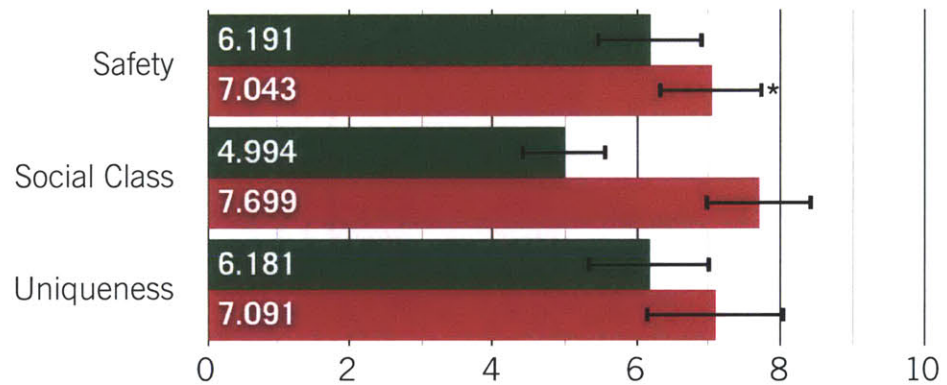
not the perception of safety (p-value = 0.3799) or uniqueness (p-value = 0.4894).

Figure 4-22
I and II show a location in Salzburg before and after adding resurfacing the road.

* = Significant at 5%



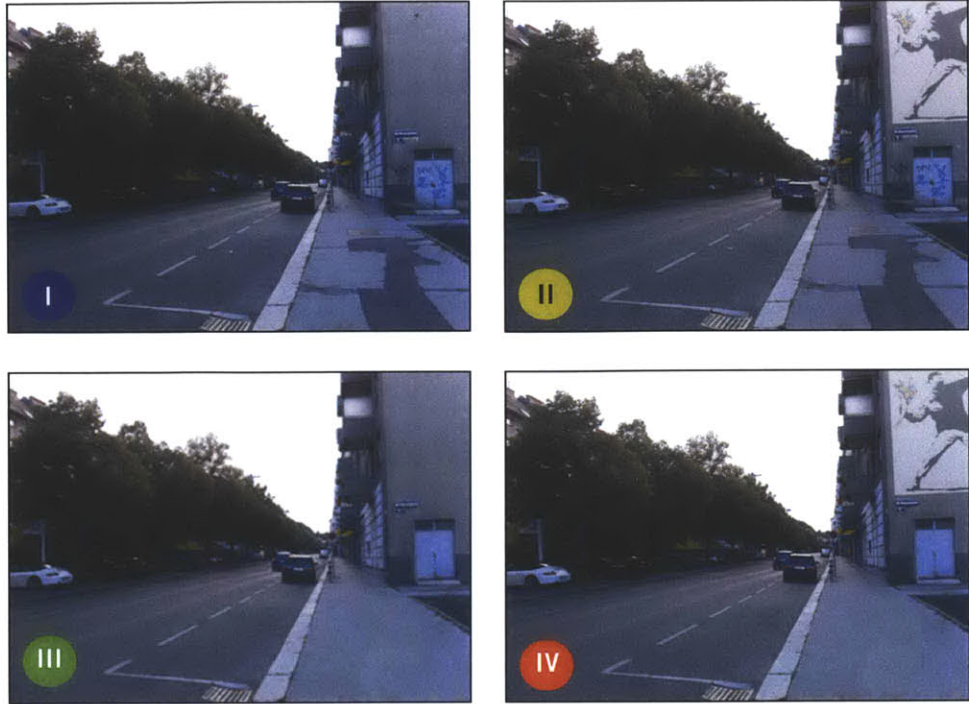
■ Original image
■ Resurfaced road and cleaned building wall



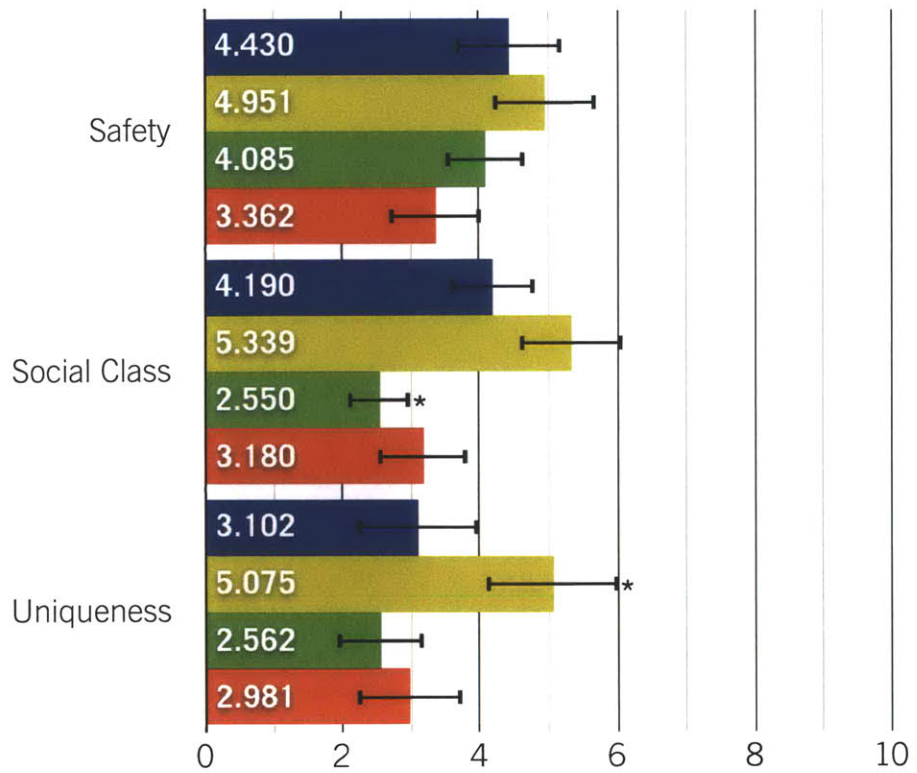
Finally, in Figure 4-23, an image from Vienna is shown where two different alterations are introduced: the addition of street art by the famous British artist Banksy (Banksy 2006) (Figure 4-23 II) and the resurfacing of the sidewalk and removal of graffiti from the wall (Figure 4-23 III). In this case, the addition of Banksy's street art (Figure 4-23 II) is associated with an increase in the perception of uniqueness that is significant (p-values < 0.05) with respect to all other modifications (Figure 4-23 I, III and IV). The sole resurfacing of the sidewalk and the removal of the graffiti tags, on the other hand, is not associated with a significant change in the Q-score obtained for any of the questions other than social class (p-value = 0.0411).

Figure 4-23
 I and II show a location in Vienna before and after adding a mural. III and IV show the removal of graffiti and cracks while IV shows a combination of all three modifications.

* = Significant at 5%



- Original image
- Added Banksy mural
- Resurfaced pavement and removed graffiti
- All three modifications (mural, pavement & graffiti)

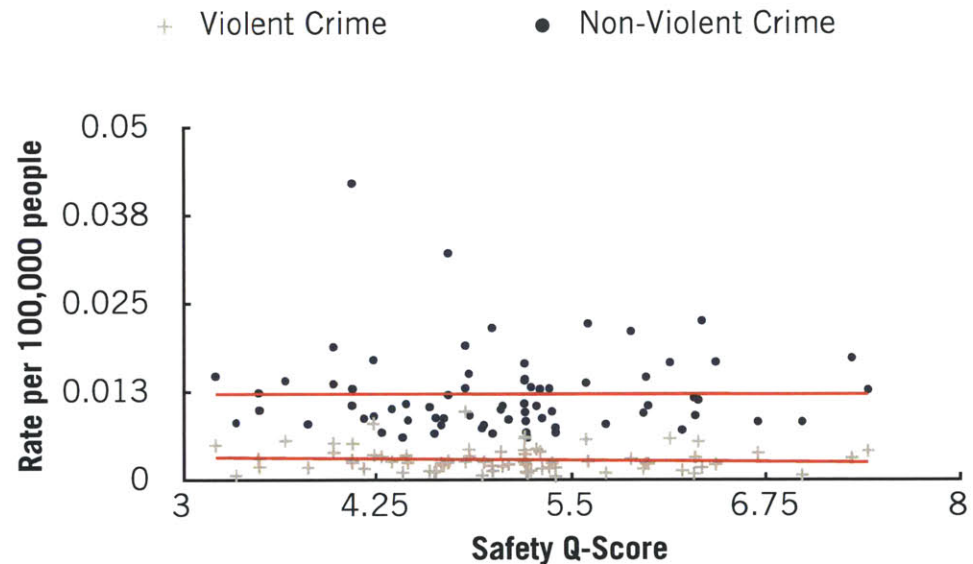


Correlation with Existing Datasets

Crime Rates

As a last piece of validation, evaluative maps obtained for NYC and Boston are compared with precinct level data on crime. Figure 4-24 compares the average Q-score of each NYC precinct with respect to violent and non-violent crime rates. The perception of safety appears to have no significant correlation with violent crime (p-value = 0.4568) or non-violent crime (p-value = 0.9908), but not with nonviolent crime.

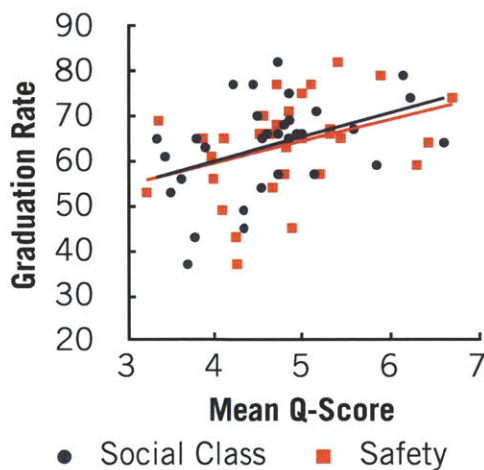
Figure 4-24
Incidents of crime and mean Q-scores for perceptions of safety in NYC. Each data point is a police precinct.



These findings support those presented by Jacinta M. Gau and Travis C. Pratt's 2008 paper published in *Criminology and Public Policy*. Their results showed that a "two-factor model [of disorder and crime] is inappropriate because of a high correlation between perceptions of disorder and crime" (Gau 2008).

High School Graduation Rates

Figure 4-25
High school graduation rates and mean Q-scores each school district in NYC for perceptions of safety and social class.



Finally, Figure 4-25 shows the correlation between the perception of social class and safety with high school graduation rates for each school district in New York City. Here, school district graduation rates were sourced from the New York State Department of Education's Accountability and Overview Reports released, available at

<http://reportcards.nysed.gov>. Figure 4-25 shows that for both perceptions of social class (blue circle) and safety (red square), there is a significant correlation between academic success and the physical environment (p-values < 0.0172). In future work, several controls will verify the veracity of this finding.

CHAPTER 5

CONCLUSIONS

“This problem, once solved, will be simple.”

-Thomas A. Edison
Inventor

In this thesis the results of a large crowdsourced study have been used to create quantitative measures of the perception that people have of urban environments. The methods presented here were used to identify locations associated with positive and negative perceptions of safety, social class and uniqueness. The throughput of the dataset presented addressed two important methodological questions: the number of responses required to obtain robust results in a comparative study, and the number of images required to get a statistically significant evaluative map of a large city.

It is worth noting that the work presented has important limitations. First, the amount of information about a place captured by an image is limited. Other sensory channels can affect perception, such as sound and smell. Also, variation in image quality (i.e. contrast,

hue, saturation, brightness, tint and clarity), as well as weather conditions, season & time of day can introduce additional source of variation in the perceptions associated with an image. These are acknowledged as important limitations of the methodology. Further research will also be required to examine whether these affects drive the results, or whether they just introduce noise. This is one of the reasons why the Place Pulse dataset is being open sourced to the community.

Despite its limitations, the potential applications of this work are vast. From a research perspective, the throughput of the methodology will allow exploring questions of global urban perception at a relatively low cost. Are the unsafe looking neighborhoods of NYC comparable to those of Sao Paulo? What is the level of perceptual inequality for different cities? The technique also opens the doors to extend the BWT to different dimensions. Are unique looking neighborhoods more innovative? Do people spend more money in areas they perceive as fun or safe?

Ultimately, social scientists, geographers and natural scientists can leverage this new layer of information to understand the effects of the urban environment in a variety of social and economic outcomes. Urban planners, on the other hand, already comfortable working with visual survey data (Appendix A) should welcome multi-city information at higher spatial resolution. This could help improve the urban design process further by providing high-resolution perception data directly to those who can affect change.

Moreover, Place Pulse data could be used by local governments to identify features that need improvement while the Place Pulse tool could be used to test potential changes before spending money on implementation.

In the future, perceptual data could also be important for online search, by providing information, for instance, on restaurants located in romantic looking areas, or scenic routes for jogging. Driving directions could be tailored to specific perceptions, allowing users to avoid areas perceived as “boring” or route through areas thought to be “beautiful.”

CHAPTER 6

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-Alvin Toffler
Futurist

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APPENDICES

Appendix A - Table of Known Visual Surveys and Scope

Authors	Year	Publication	Images	Subjects	Responses
Wilson	1962	Livability of the City: Attitudes & Urban Development	34		
Peterson	1967	Journal of Regional Science	100	140	3,220
Kaplan et al	1972	Perception & Psychophysics		88	4,928
Herzog et al	1976	Environment and Behavior	86	121	10,406
Nasar	1984	Journal of Cross-Cultural Psychology	24	46	1,104
Devlin & Nasar	1989	Journal of Environmental Psychology	40	40	1,600
Steinitz	1990	Landscape & Urban Planning	48	200	
Hammitt & Patterson	1994	Landscape & Urban Planning	96	721	

Authors	Year	Publication	Images	Subjects	Responses
Bishop	1997	Landscape & Urban Planning	100	59	708
Hunker & Kienast	1999	Landscape Ecology	1	181	1,267
Wherrett	1999	Landscape & Urban Planning	90	165	3,300
Ayala	2000	Landscape & Urban Planning	176	150	
Cohen et al	2000	American Journal of Public Health	55		
Wherrett	2000	Landscape & Urban Planning	90	180	3,600
Brown	2001	Landscape & Urban Planning	32	60	
Daniel & Meitner	2001	Journal of Environmental Psychology		216	10,368
Ross & Mirosky	2001	Journal of Health & Social Behavior		2,482	2,482
Arriaza et al	2003	Landscape & Urban Planning	160	226	
De Groot	2003	Landscape & Urban Planning		172	
Dramstad et al	2006	Landscape & Urban Planning	30	91	
Roth	2005	Landscape & Urban Planning		321	1477
Vandenberg	2006	Landscape & Urban Planning	225	500	
Rogge et al	2007	Landscape & Urban Planning	330	130	
Barga & Bond	2008	American Journal of Criminology	34		
Keizer et al	2008	Science	12	589	589