Social Street View: Blending Immersive Street Views with Geo-tagged Social Media





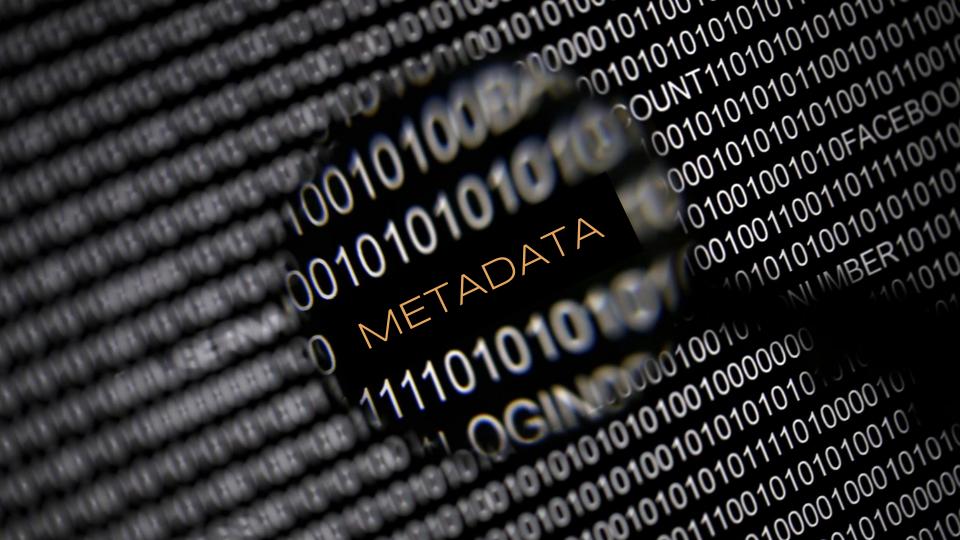
Introduction Social Media















Introduction





Linear narrative visualization







image courtesy: instagram.com, facebook.com, twitter.com

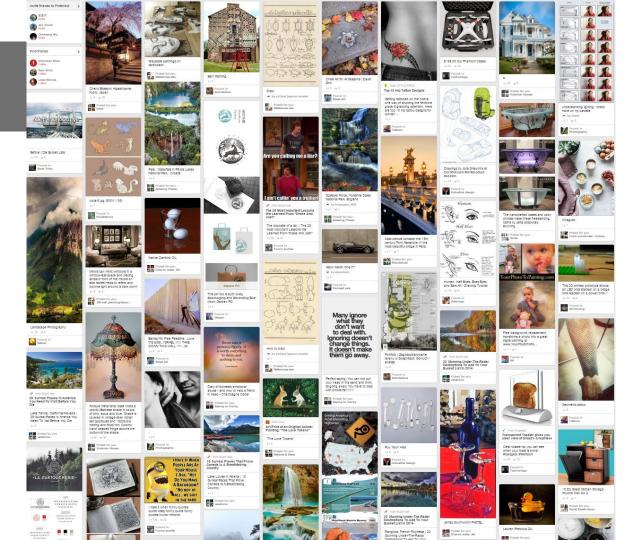


image courtesy: pinterest.com

Natural Immersive Virtual Reality?



Karnath et al. and Loomis et al.



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function is largely based on the belief that spatial neglect in humans (a lack of awareness of space on the side of the body contralateral to a brain injury) is typically associated with lesions of the posterior parietal lobe. However, in monkeys, this disorder is observed after lesions of the superior temporal cortex', a puzzling discrepancy between the species. Here we show that, contrary to the widely accepted view, the superior temporal cortex is the neural substrate of spatial neglect in humans, as it is in monkeys. Unlike the monkey brain, spatial awareness in humans is a function largely confined to the right superior temporal cortex, a location topographically reminiscent of that for language on the left². Hence, the decisive phylogenetic transition from monkey to human brain seems to be a restriction of a formerly bilateral function to the right side, rather than a shift from the temporal to the parietal lobe. One may speculate that this lateralization of spatial awareness parallels the emergence of a

elaborate representation for language on the left side. Spatial neglect is a characteristic failure to explore the side

space contralateral to a brain lesion. Patients with this disor behave as if one side of the surrounding space had ceased to ex Since the early post-mortem studies, we have believed that humans, lesions located predominantly in the posterior par lobe are critical for this disorder. Analyses of computerized to raphy scans of right-hemispheric stroke patients with neglect that superimposed lateral projections of these lesions centred inferior parietal lobule (IPL)³⁴ and the temporo-parieto-o (TPO) junction⁴. More recent studies have confirmed the va this conclusion although evidence for additional pathology NATURE VOL 411 21 JUNE 2001 www.nat

Behavior Research Methods, Instruments, & Computers

Immersive virtual environment technology as a basic research tool in psychology

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Immersive virtual environment (IVE) technology has great promise as a tool for basic experimental research in psychology. IVE technology gives participants the experience of being surrounded by the computer synthesized environment. We begin with a discussion of the various devices needed to implement immersive virtual environments, including object manipulation and social interaction. We repreners interests variant environments, incruding object manipulation and social interaction. In the view the benefits and drawbacks associated with virtual environment technology, in comparison with more conventional ways of doing basic experimental research. We then consider a variety of examples of research using IVE technology in the areas of perception, spatial cognition, and social interaction.

Human history records a progression of artifacts for representing and recreating aspects of external reality, ranging from language, drawings, and sculpture in earlier times to the more modern artifacts of photographs, movies, television, and audio recordings. Relatively recently, the digital computer and its associated technologies, including three-dimensional (3-D) graphics, have given rise to increasingly realistic artifacts that blur the distinction between reality and its representation (Ellis, 1995).

The ultimate representational system would allow the observer to interact "naturally" with objects and other individuals within a simulated environment or "world," an experience indistinguishable from "normal reality." Although such a representational system might conceivably use direct brain stimulation in the future, it will more likely use digitally controlled displays that stimulate the human sensory organs, the natural conduits to the brain. Displays of this type, referred to as virtual displays (VDs), although far from ideal, exist today. Following the terminology of others (e.g., Durlach & Mavor, 1995; Stanney & Salvendy, 1998), we refer to the corresponding environment represented and stored in the computer and experienced by the user as a virtual environment (VE). Virtual environment technology (VET) refers inclusively both to VDs and to the VEs so created, including VEs produced by using conventional desktop computer displays.

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(Virtual reality is widely used as an alternative term, but we prefer VE.) An immersive virtual environment (IVE) is one in which the user is perceptually surrounded by the VE. Ivan Sutherland (1965), one of the originators of 3-D computer graphics, was the first person to conceive and build an immersive VD system. For the history of IVEs,

see Ellis (1995), Kalawsky (1993), and Rheingold (1991). There are two usual implementations of an IVE. The first of these involves placing multiple projection screens and loudspeakers around the user. A popular design is the CAVE (Cruz-Neira, Sandin, & DeFantini, 1993), which involves back-projecting the computer-generated visual imagery onto the translucent walls, floor, and ceiling of a moderately sized cubical room, in which the user is free to move; shutter glasses provide stereoscopic stimulation, so that one sees the VE not as projections on the room surfaces, but as solid 3-D structures within and/or outside of the cube. The second and more common implementation of an IVE involves the use of a head-mounted display (HMD), used in conjunction with a computer and a head tracker (Barfield & Furness, 1995; Biocca & Delaney, 1995; Burdea & Coiffett, 1994; Durlach & Mavor, 1995; Kalawsky, 1993). The head tracker measures the changing position and orientation of the user's head within the physical environment, information that is communicated to the rendering computer, which has stored within it a 3-D representation of the simulated environment (Meyer, Applewhite, & Biocca, 1992). At any given moment, the computer generates and outputs the visual and auditory imagery to the user's HMD from a perspective that is based on the position and orientation of the user's head. The HMD consists of earphones and video displays attached to a support worn on the head; the video display component is based on cathode ray tube (CRT) displays, liquid crystal displays, or laser-based retinal scanners (Barfield, Hendrix, Bjorneseth, Kaczmarek, &

Visualization of Geo-tagged Information

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Twitter is an electronic medium that allows a large user poprecent to incritter is an asymmetrical relationship between friends and followers that provides an interesting social network- 1. INTRODUCTION ulace to communicate with each other simultaneously. Inherent to Twitter is an asymmetrical relationship between like structure among the users of Twitter. Twitter messages, called tweets, are restricted to 140 characters and thus are usually very focused. We investigate the use of Twitter to build a news processing system, called TwitterStand, from Twitter tweets. The idea is to capture tweets that correspond to late breaking news. The result is analogous to a distributed news wire service. The difference is that the identitles of the contributors/reporters are not known in advance and there may be many of them. Furthermore, tweets are not sent according to a schedule: they occur as news is happening, and tend to be noisy while usually arriving at a high throughput rate. Some of the issues addressed include removing the noise, determining tweet clusters of interest bearing in mind that the methods must be online, and determining the relevant locations associated with the tweets.

Categories and Subject Descriptors H.3 [Information Storage and Retrieval]: Information

Storage and Retrieval

General Terms

Algorithms, Design, Performance

*This work was supported in part by the National Science LIDS WORK Was supported in part by the National Science Foundation under Grants EIA-08-12377, CCF-08-30618, and roundation under Grants EIA-08-12377, CCF-08-30018, and IIS-07-13501, as well as NVIDIA Corporation, Microsoft Re-115-07-16501, as well as NV1D1A Corporation, successful Re-search, Google, the E.T.S. Walton Visitor Award of the Sci-gnce Foundation of Ireland, and the National Center for ence roundacion or ireaand, and the iracional center ior Geocomputation at the National University of Ireland at

Department of Computer Science, Center for Automation Research, Institute for Advanced Computer Studies, University of Maryland, College Park, MD 20742, USA. ¹HUD Office of Policy Development & Research (PD&R), 451 7th St. SW, Room 8146, Washington, DC 20410, USA.

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Twitter, News, Geotagging, Online clustering

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Twitter¹ is a social networking website that recently has been gaining much attention and following. Twitter is composed of users who send messages (termed tweets) to each other, where each tweet contains a maximum of 140 characters. At this time, it is estimated that there are 6 to 7 million users who use Twitter a total of 134 million times a month [4], and this number is increasing at a rapid rate. For example, for the year of 2008, Twitter grew in terms of the number of tweets sent at a rate of 1382% [12] which is a testament to the immense popularity and wide adoption of this service. The popularity of Twitter stems from its availability on a number of different electronic devices (e.g., web, cell phones, etc.), as well as the prevalence of a subculture in Twitter that encourages users to acquire a large friend pool, as well as send tweets on a wide variety of subjects, typically several times a day. The restriction on the lengths of Twitter messages invariably means that the tweets do not necessarily contain well formed ideas, being rather brief, yet complete enough so that users can make sense of the ideas that they convey. Note that tweets also have a mechanism by which the user can link to other objects on the web such as articles, images, videos, etc. (termed artifacts) which is typically used

to link tweets to related material on the Internet. The goal of this paper is to demonstrate how to use Twitter to automatically obtain breaking news from the tweets

posted by Twitter users, and to provide a map interface for reading this news, since the geographic location of the user as well as the geographic terms comprising the tweets play as wen as the geographic terms comprising the tweets and establishing clus-an important role in *clustering* tweets and establishing clusters' geographic foci. In contrast to news aggregators such as Google News, Bing News, and Yahoo! News, we introduce a system called TwitterStand that works exclusively with only the tweets posted by the users of Twitter. The key novely behind TwitterStand is one of mobilizing the millions of users in Twitter to be our eyes and ears in the world, bearing in mind that geographically proximate users often tweet about the same breaking news. In other words, we rely on Twitter users to be either providers of original news content (e.g., the 2008 Southern California earthquake [13] and the 2009 Iranian election [3]), or expressers of opinions on current news topics (i.e., mini blogs), both of which enable TwitterStand to automatically identify current news topics and cluster the corresponding tweets into appropriate news stories. We also associate an importance score with each news topic which can



Twitter is an electronic medium that allows a large user popwhere is an execution meaning one and part ulace to communicate with each other simultaneously. Inherent to Twitter is an asymmetrical relationship between friends and followers that provides an interesting social networklike structure among the users of Twitter. Twitter messages, called tweets, are restricted to 140 characters and thus are usually very focused. We investigate the use of Twitter to build a news processing system, called TwitterStand, from Twitter tweets. The idea is to capture tweets that correspond to late breaking news. The result is analogous to a distributed news wire service. The difference is that the identities of the contributors/reporters are not known in advance and there may be many of them. Furthermore, tweets are not sent according to a schedule: they occur as news is happening, and tend to be noisy while usually arriving at a high throughput rate. Some of the issues addressed include removing the noise, determining tweet clusters of interest bearing in mind that the methods must be online, and determining the relevant locations associated with the tweets.

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ABSTRACT

In this paper we investigate generic methods for placing photos uploaded to Flickr on the World map. As primary input for our methods we use the textual annotations provided by the users to predict the single most probable location where the image was taken. Central to our approach is a language model based entirely on the annotations provided by users. We define extensions to improve over the language model using tag-based smoothing and cell-based smoothing, and leveraging spatial ambiguity. Further we demonstrate how to incorporate GeoNames¹, a large external database of locations. For varying levels of granularity, we are able to place images on a map with at least twice the precision of the state-of-the-art reported in the literature.

Categories and Subject Descriptors

H.3.3 [Information Search and Retrieval]

General Terms

Algorithms, Measurement, Performance, Experimentation

Keywords

image localisation, language models, Flickr

1. INTRODUCTION

Due to the massive production of affordable GPS-enabled cameras and mobile phones [13, 16], location metadata such as latitude and longitude are automatically associated with the content generated by users. Users have the opportunity to spatially organise and browse their personal media, and photo sharing services are leading the growing enthusiasm

for personal location-awareness [22]. Geo-referenced photos *Research performed while the author was an intern at Yahoo! Research. [†]Also affiliated with TU Delft, ICT Group

¹http://www.geonames.org visited Ma

Placing Flickr Photos on a Map

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can be organised in a browsable taxonomy of major locations or pin-pointed on a map to identify very small regions. Some of the most popular examples are Flickr Places² and Google

While in theory every photo can be anchored to the location it was taken, in practice many photos are location agnostic. Furthermore, the majority of Flickr users do not own location-aware cameras. Thus a large proportion of photos uploaded to Flickr contain no location information even when the photo merits localizing. When uploading photos on Flickr users can still geo-tag their photos by dragging the photos to a particular point on the world map. This process is time-consuming and results in less accurate geo-tagging of photos compared to automatically geo-tagged photos from GPS-enabled cameras. When manually geo-tagging photos, Flickr initially suggests the location of the last uploaded photo or simply displays the world map.

The objective of this paper is to provide a more accurate starting point for geo-tagging photos, uploaded on Flickr, using the textual annotations provided by the user. According to recent literature [2, 21] users spend considerable effort to organise their "memory" geographically by describing photos with tags related to locations where they were taken. The location specific tags (such as Torre Agbar which is only located in Barcelona), and location related tags (such as elephants which are related to locations such as zoos, Africa and Asia) provide essential cues as to where a picture was taken. For photos that are location agnostic (such as dog), location information may or may not be provided, but it is normally not relevant to the context of the photo.

The literature related to geo-tagging of photos and its use is extensive. In particular the reverse problem of discovering important landmarks and events, given a geographic co-ordinate has been studied extensively [1, 17, 13]. However the problem of placing images on a map using the textual annotations provided by the user has received less attention.

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Keywords Twitter, News, Geotagging, Onlin

1. INTRODUCTION Twitter¹ is a social networki been gaining much attention as posed of users who send mess other, where each tweet cont acters. At this time, it is es million users who use Twitt a month [4], and this numb For example, for the year of the number of tweets sent a testament to the immense this service. The populari

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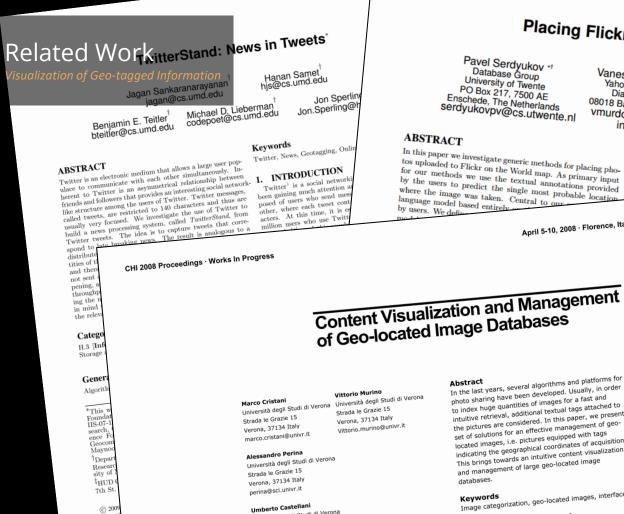
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Content Visualization and Management of Geo-located Image Databases

In the last years, several algorithms and platforms for photo sharing have been developed. Usually, in order to index huge quantities of images for a fast and intuitive retrieval, additional textual tags attached to the pictures are considered. In this paper, we present a set of solutions for an effective management of geolocated images, i.e. pictures equipped with tags indicating the geographical coordinates of acquisition. This brings towards an intuitive content visualization and management of large geo-located image

Image categorization, geo-located images, interfaces

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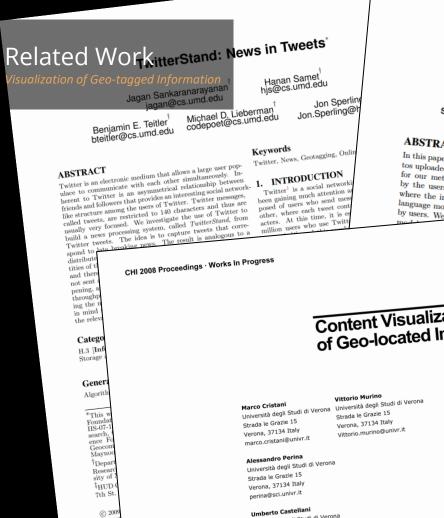
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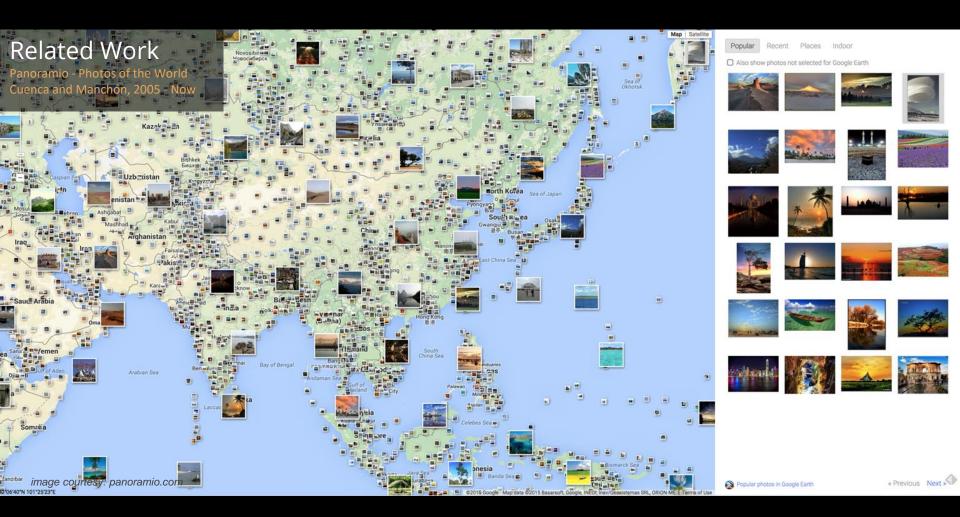
Placing Flickr Photos on a Map Pavel Serdyukov + Database Group Vanessa Murdock University of Twente Yahoo! Research Roelof van Zwol PO Box 217, 7500 AE Diagonal 177 Yahoo! Research Enschede, The Netherlands 08018 Barcelona, Spain serdyukovpv@cs.utwente.nl Diagonal 177 vmurdock@yahoo-08018 Barcelona, Spain roelof@yahoo-inc.com inc.com ABSTRACT In this paper we investig tos uploaded to Flickr o for our methods we us by the users to predict PhotoStand: A Map Query Interface for a Database of News where the image was to language model based e by users. We defin Photos-Hanan Samet Marco D. Adelfio Brendan C. Fruin Michael D. Lieberman Jagan Sankaranarayanan Center for Automation Research, Institute for Advanced Studies, Department of Computer Science, University of Maryland College Park, MD 20742 USA {hjs, marco, brendan, codepoet, jagan}@cs.umd.edu ABSTRACT **Content Visualization** articles, enabling them to be accessed by spatial queries such PhotoStand enables the use of a map query interface to retrieve as windowing or simple point location; and its clusterer [30], of Geo-located Image news photos associated with news articles that are in turn assowhich groups articles about the same topic. A key to the Newsciated with the principal locations that they mention collected Stand database system is its pipe server which coordinates its as a result of monitoring the output of over 10,000 RSS news processing modules by assigning batches of articles to them. feeds, made available within minutes of publication, and stored NewsStand's user interface enables the retrieval of clusters of in a PostgreSQL database. The news photos are ranked according to their relevance to the clusters of news articles associated news articles for display using its map user interface by executing what we term top-k window queries. At present, NewsStand with locations at which they are displayed. This work differs handles about 50K articles per day and has a large underlying from traditional work in this field as the associated locations Abstrac database of articles currently containing about 300GB of data. and topics (by virtue of the cluster with which the articles In the las The PhotoStand and TweetPhoto [3] demos are related in containing the news photos are associated) are generated auphoto sh the sense that PhotoStand uses photos from news articles in tomatically without any human intervention such as tagging, to index NewsStand, while TweetPhoto uses photos from news tweets in and that photos are retrieved by location instead of just by TwitterStand [24]. In addition, the PhotoStand demo demonintuitive keyword as is the case for many existing systems. In addition, strates the database querying capability of NewsStand as well the pict the clusters provide a filtering step for detecting near-duplicate as its capability to do similarity searching for news photos set of s where the first step in the similarity detection process is based locate 1. INTRODUCTION on the text associated with the photos, while the second step indica A demo is presented of PhotoStand (see also the related involves use of the actual image features (e.g., texture, color) to This t NewsStand [9, 17, 21, 29], TwitterStand [6, 24], and STEWenable detecting near duplicates, thereby avoiding the combiand n ARD [12] systems) which is an example application of a general natorial complexity of comparing every photo with every other datat framework we are developing for retrieving multimedia data (e.g., text, images, videos) using a map query interface from

a database of news articles, photos, and videos (i.e., by lo-

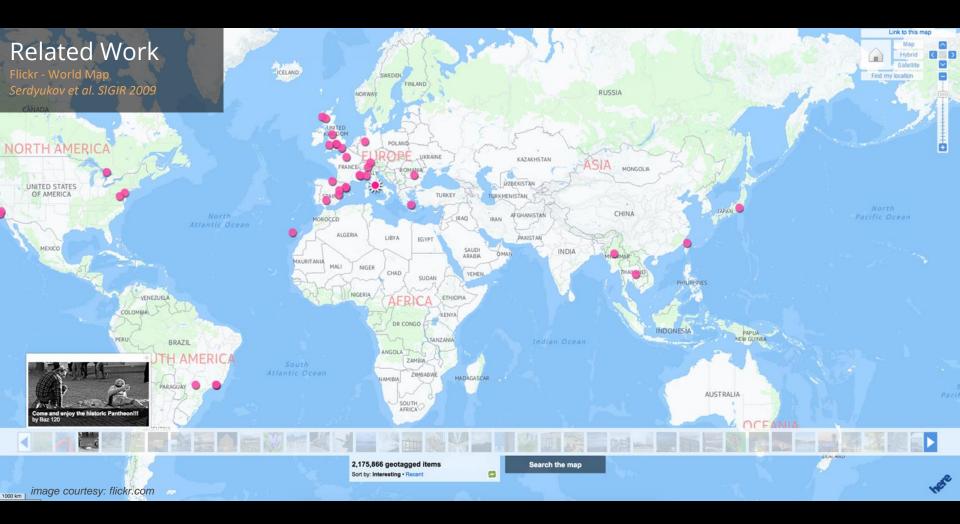
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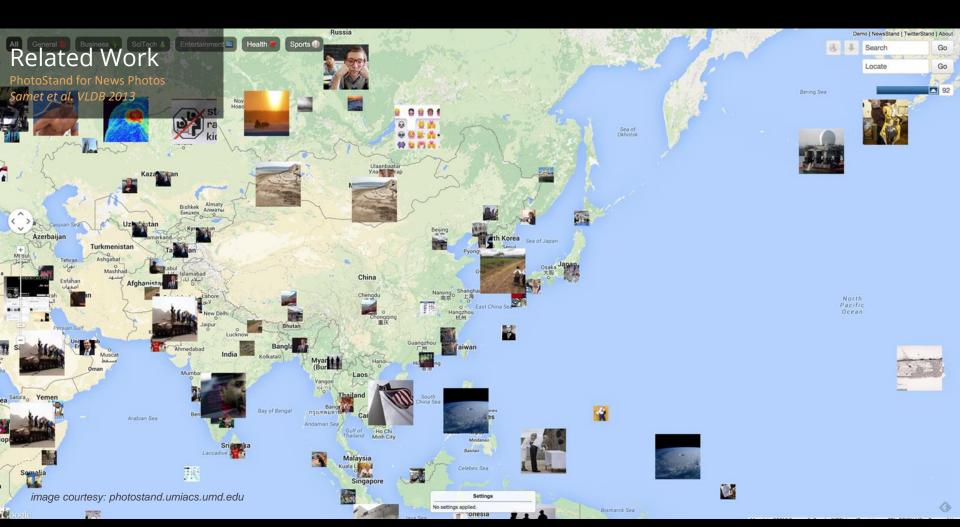
Imag

The rest of this paper is organized as follows. Section 2 discusses related work. Section 3 indicates how news articles (and consequently news photos) a









Visualization of Geo-tagged Information (cont.)

Visualization of Geo-tagged Information (cont.) UIST 2001 (ACM Symp. on User Interface Software and Technology), Orlando, FL, November 11-14, 2001, pp. 101-110 View Management for Virtual and Augmented Reality Department of Computer Science 500 W 120th St., 450 CS Building Blaine Bell Columbia University New York, NY 10027 (bell,feiner,htobias)@cs.columbia.edu avoid occlusion. Layout decisions from previous frames are avoid occusion. Layout decisions from previous transes are taken into account to reduce visual discontinuities. We taken into account to reduce visual discontinuities. We not account to reduce visual discontinuities we have a second reduct and visual reality examples to account account of the second reduct account of the second redu present augmented rearry and virtual rearry examples to which we have applied our approach, including a which we have applied our approach, in dynamically labeled and annotated environment. ABSTRACT We describe a view-management component for interactive We describe a view-management component for interactive 3D user interfaces. By view management, we mean environment view means are done environment of education D user interfaces. By view management, we mean maintaining visual constraints on the projections of objects are because and the transformation of the second manualizing visual constraints on the projections of objects on the view flame, such as locating related objects near each other or manufactor strained from manufactor manufactor of the on the view plane, such as locating related objects near each object of preventing objects from occluding each other. Our view management - compared - and other, or preventing objects from occluding each other. Our view-management component accompliance this by view-management component accompliance units by modifying selected object properties, including position, montying selected opect properties, including position, size, and transpatency, which are tagged to indicate their constraints. For example, some objects may have operative size, and transparency, which are lagged to indicate their constraints. For example, some objects may have geometric Additional Keywords and Phrases view management. constraints for example, some objects may have geometric properties that are determined entirely by a physical instantion and which encode the evolution while while properties that are performed entirely by a physical simulation and which cannot be modified, while other states and the modified while other states and the states are states and the states are states and the states are simulation and which cannot be modified, while other objects may be anotations whose position and size are objective. We introduce algorithms that use upright rectangular We infroduce algorithms that use upright rectanguard extents to represent on the view plane 3 dynamic and articles are represented as a consistent encode contained extents to represent on the view plane a dynamic and efficient approximation of the occupied space outaining the metalement of window working of The objects we could appear efficient approximation of the occupied space containing the projections of visible portions of 3D objects, as well as the projections of visible portions of 3D objects, as well as the unoccupied space in which objects can be placed to

Noningent Networks and Pleases view management, environment management, anotation, labeling, wearable committee suscented reality committee environment environment management, annotation, tabeling, w computing, augmented reality, virtual environments 1. INTRODUCTION Designing a 3D graphical user interface (UI) requires continue a net of during and their momentum Designing a 3D graphical user interface (UI) requires creating a set of objects and their properties, arranging them in a contrast setting a viewance monotication. Automation creating a set of objects and their properties, arranging them in a scene, setting a viewing specification, determining liabiting and rendering memory and determining the In a seene, seeing a viewing specification, deforming lighting and rendering parameters, and deciding how to induse how deriviewe for such frame. Score of twolighting and rendering parameters, and deciding how to update these decisions for each frame. Some of these update these decisions for each frame, some of these decisions may be fully constrained. for example, a eccisions may be fully constrained, for example, a mission may determine the position and shape of certain. hay determine the position and snape or certain the viewine specification may be explicitly Accurvation may be explicitly contrast, other decisions must be specially interested in

CR Categories and Subject Descriptors: 115.1 CR Categories and Subject Descriptors [15.] [Information Interfaces and Presentation] Multimedia Information Interfaces and Presentation) Multimedia Information Interfaces—Artificial, augmented, and virtual environmenter us complete the sectors and realmes, H-3-2 Information Interfaces and Presentation User Interfaces-Graphical User Interfaces Presentation) User interlaces_uraphical User Interlaces. Sector design, 13.6 [Computer Graphics] Methodology Screen design, 13.5 Vomputer Graphics JARDBG00089 and Techniques-Interaction Techniques, 13.7 (Computer Genetics) Theoreticsment Graphics and Boalance and Techniques—Interaction Techniques; 13.7 [Computer Graphics] Three-Dimensional Graphics and Realism— Filtered Realism

Visualization of Geo-tagged Information (cont.)





We describe a view-man. ABSTRACT 3D user interfaces. By anaintaining visual constr on the view plane, such a other, or preventing obj view-management con modifying selected obj size, and transparency, constraints. For examp properties that are simulation and which objects may be anne flexible. We introduce algo extents to represen efficient approxima the projections of v the unoccupied sp. Photo Tourism: Exploring Photo Collections in 3D Steven M. Seitz University of Washington Noah Snavely University of Washington



Figure 1: Our system takes unstructured collections of photographs such as those from online image searches (a) and reconstructs 3D points and viewpoints (b) to enable novel ways of browsing the photos (c).

We present a system for interactively browsing and exploring large we present a synem or interactively newsing and expressing ange-unstructured collections of photographs of a scene using a novel 3D interface. Our system consists of an image-based modeling front end that automatically computes the viewpoint of each photograph as well as a sparse 3D model of the scene and image to model uran as wen as a sparse are insured in the section and image to masses correspondences. Our photo explorer uses image-based rendering techniques to smoothly transition between photographs, while also enabling full 3D navigation and exploration of the set of images and world geometry, along with auxiliary information such as overhead maps. Our system also makes it easy to construct photo tours of scenic or historic locations, and to annotate image details, which are automatically transferred to other relevant images. We demonare automatically transferred to other feetware images, we because strate our system on several large personal photo collections as well

as images gathered from Internet photo sharing sites. CR Categories: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities 1.2.10 [Artificial Intelligence]: Vision and Scene Understanding—Modeling and recovery of physical attributes Keywords: image-based rendering, image-based modeling, photo

browsing, structure from motion

1 Introduction

ed of image-based rendering is to evoke a visceral sense

is that these approaches will one day allow virtual tourism of the During this same time, digital photography, together with the Inworld's interesting and important sites. ternet, have combined to enable sharing of photographs on a truly ternet, nave commune a to ensure smaring or provographics on a usual massive scale. For example, a Google image search on "Notre massive scate. For example, a Guyger mage scate on ventor Dame Cathedral" returns over 15,000 photos, capturing the scene from myriad viewpoints, levels of detail, lighting conditions, seasons, decades, and so forth. Unfortunately, the proliferation of shirs, uccaues, and so intui. Outorunanety, use positionation of shared photographs has outpaced the technology for browsing such collections, as tools like Google (www.google.com) and Flickr

(c)

Microsoft Research

(www.flickr.com) return pages and pages of thumbnails that the In this paper, we present a system for browsing and organizing

an una paper, no present a system on moving and an angunating the system of provide the common 3D geometry of the underlying scene. Our approach is based on computing, from the images themselves, the photographers' locations and orientations, along with a sparse 3D geometric representation of the scene, using a state-of-the-art image-based modeling system. Our system handles large collections of unorganized phoographs taken by different cameras in widely different conditions. We show how the inferred camera and scene information enables

 Scene visualization. Fly around popular world sites in 3D by the following capabilities:

- Object-based photo browsing. Show me more images that
- contain this object or part of the scene. Where was 1? Tell me where 1 was when 1 took this picture. What am I looking at? Tell me about objects visible in this
- image by transferring annotations from similar images.
- image-based

Visualization of Geo-tagged Information (cont.)



We describe a view-mani. ABSTRACT 3D user interfaces. By maintaining visual constr on the view plane, such a other, or preventing obj view-management modifying selected obj size, and transparency constraints. For examp properties that are simulation and which objects may be anne flexible. We introduce algo. extents to represen efficient approxima the projections of v

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Photo Tourism: E

Noah Snavely University of Washington



Figure 1: Our system takes unstructured coll and viewpoints (b) to enable novel ways of

Abstract

We present a system for interactively bro unstructured collections of photographs 3D interface. Our system consists of front end that automatically computes the graph as well as a sparse 3D model of th correspondences. Our photo explorer techniques to smoothly transition bety enabling full 3D navigation and explo world geometry, along with auxiliary maps. Our system also makes it ea scenic or historic locations, and to are automatically transferred to oth strate our system on several large p as images gathered from Internet p

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1 Introduction

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Social Snapshot: A System for Temporally Coupled **Social Photography**

Robert Patro, Cheuk Yiu Ip, Sujal Bista, and Amitabh Varshney - University of Maryland, College Park

ince the invention of photography, taking pictures of people, places, and activities has become integral to our lives. In the past, only purposeful, precious moments were the primary subjects of photography. But technological advances have brought photography to our everyday lives in the form of compact cameras and even cell phone cameras. The next phase in the photog-

raphy revolution, 3D photogra-

phy, can bring users together to

socialize and collaboratively take

pictures in an entirely new way.

However, transforming a pho-

tographic scene from 2D to 3D

requires introducing multiple im-

ages of the same underlying ge-

ometry from different viewpoints.

The reconstruction of 3D geom-

etry from multiple overlapping

images is the classic structure-

Social Snapshot actively acquires and reconstructs temporally dynamic data. The system enables spatiotemporal 3D photography using commodity devices, assisted by their auxiliary sensors and network functionality. It engages users, making them active rather than passive participants in data acquisition.

from-motion (SFM) problem in computer vision. Typically, the instruments used to acquire photographs are tediously calibrated to produce precise measurements.

To simplify 3D photography, our Social Snapshot system performs active acquisition and reconstruction of temporally dynamic data. Using multiple users' cell phone cameras and no preliminary calibration, it achieves approximate but visually convincing renderings of 3D scenes even though

Social Snapshot's Contributions

Social Snapshot's contributions fit naturally into two categories: technical and social.

The technical contributions are improved algorithms and techniques that enhance our system's novelty and scalability. For example, Social Snapshot produces a textured and colored-mesh reconstruction from a loosely ordered photo collection, rather than the sparse or dense point reconstructions produced by related approaches. In addition, it features locally optimized mesh generation and viewing. Finally, it provides camera network capabilities to support synchronized capture of temporally dynamic data.

The social contributions lead to a new way of thinking about the interplay between data acquisition and social interactions. They also let us define social photography as an active, rather than a passive, endeavor. For example, Social Snapshot encourages collaborative photography as a social endeavor, letting users capture dynamic action by synchronizing their photographs. It leverages social trends such as online media sharing and event organization to spur a novel data acquisi-

For a look at some of the previous research on which Social Snapshot is based, see the "Related Work in Scene Visualization and Computer Vision" sidebar on pages 78-79.

Visualization of Geo-tagged Information (cont.)





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Figure 1: Given a reference text describing a specific site, for example the Wikipedia article above for the Pantheon, we automatically created a labeled 3D reconstruction with objects in the novelal laded to where they are mentioned in the text. The user interface enables coordinated Figure 1: Given a reference text describing a specific site, for example the Wikipedia article above for the Pantheon, we automatically create a labeled 3D reconstruction, with objects in the model linked to where they are mentioned in the text. The user interface enables coordinated

Bryan C. Russell1

We introduce an approach for analyzing Wikipedia and other text, re-inconnec an approach for analyzing vertapeous and other text, logether with online photos, to produce annotated 3D models of togener with onnine photos, to produce annuaries are interests of amous tourist sites. The approach is completely automated, and another the start and about on annuaries with Foundation and tennous stuties such the approach is composing automatical and leverages online text and photo co-occurrences via Google Image reverges tomme text and proto co-occurrences via coager times. Search, It enables a number of new interactions, which we demonscatch, it changes a manufer to new interaction, which we seeman strate in a new 3D visualization tool. Text can be selected to move strate in a new stry visualization foor. Text can be selected to move the camera to the corresponding objects, 3D bounding boxes prothe canara at the contraponantly objects, so tomanating toxics pro-vide anchors back to the text describing them, and the overall harrate unstance one to the text occurring sterns, and the overall that a rative of the text provides a temporal guide for automatically flying rative or the text provides a temporal guide for automaticany nying through the scene to visualize the world as you read about it. We

show compelling results on several major tourist sites. CR Categories: H.5.1 [Information Interfaces and Presenta-

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Keywords: image-based modeling and rendering, Wikipedia, nat-Links: OL PDF

1 Introduction

3D Wikipedia: Using online text to automatically label and navigate reconstructed geometry

Daniel J. Butler²

²University of Washington

Steven M. Seitz²

Luke Zettlemoyer²

1 Intel Labs

Tourists have long relied on guidebooks and other reference texts to learn about and navigate sites of interest. While guidebooks are packed with interesting historical facts and descriptions of siles specific objects and spaces, it can be difficult to fully visualize the specific objects and spaces, it can be difficult to fully visuance the scenes they present. The primary cues come from images provided with the text, but coverage is sparse and it can be difficult to unwith the text, but coverage is sparse and it can be uniterial to un-derstand the spatial relationships between each image viewpoint. cersuanti the spatial relationships between cach intage viewpoint. For example, the Berlitz and Lonely Planet guides [Berlitz In-For example, the Berniz and Lonety riance guides (Derniz in-ternational 2003; Garwood and Hole 2012) for Rome each conternational 2015; Uarwood and Hote 2014] for Kome each con-tain just a single photo of the Pantheon, and have a similar lack of photographic coverage of other sites. Even online sites such or pnotographic coverage or other sites. Even online Mites Mites and as Wikipedia, which do not have space restrictions, have similarly

Instead of relying exclusively on static images embedded in text,

suppose you could create an interactive, photorealistic visualizasuppose you could create an interactive, pursurventative variance tion, where, for example, a Wikipedia page is shown next to a detun, where, an example, a whapsain page is shown these to a use tailed 3D model of the described site. When you select an object (e.g., "Raphaels tomb") in the text, it flies you to the corresponding location in the scene via a smooth, photorealistic transition. Simiteranta in the sector the a minimum production to the visualization, it highlight anty, when you creek on an object in one visualization, a ingungation the corresponding descriptive text on the Wikipedia page. Our goal the corresponding used sprace test on the property leaves and the second s

Visualization of Geo-tagged Information (cont.)





Photo Tourism: E

Noah Snavely University of Washington

Figure 1: Our system takes unstructured coll and viewpoints (b) to enable novel ways of h

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Figure 1: Given a reference text de a labeled 3D reconstruction, with (browsing of the text with the visue

Abstract

together with online photos, to famous tourist sites. The app leverages online text and phot Search. It enables a number of strate in a new 3D visualizati the camera to the correspond vide anchors back to the tex rative of the text provides a through the scene to visual show compelling results or

Processing-Text analy and Scene Understandir

Ricardo Ma Pantheon, Re

Bryan C. Russell1

We introduce an approach for a

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Figure 1: Web-based visualisation of multimodal data recorded on set (LDAR, static image reconstruction, and witness video) Abstract In this paper, we present a web application for the hybrid visuali sation of digital production Big Data. In a troical film or television In this paper, we present a web application for the hybrid visuali-sation of digital production Big Data. In a typical film or television production, several terabytes of data can be recorded her day. such sation of digital production big Data. In a typical tilm or television production, several terabytes of data can be recorded per day, such as film from multisher connerse or backonsumd information Production, sciencial terabytes of data can be recorded per day, such as film footage from multiple cancers or background information teraarding the set. Interactive visualisation of this multimodal data. as film footige from multiple conterns or background information regarding the set. Interactive visualisation of this multimodal data internative 2D (immees and video) and D examines multi-content data would be approximately and the set of regarding the set. Interactive visualisation of this multimodal data integrating 2D (image and video) and 3D graphice modes, model ensute in enhanced use, A hernweet-based context is canable of this integrating 2D (image and video) and 3D graphics modes. Would result in enhanced use. A browser-based context is capable of this integration in a seamless and onservice imagines but faces atomic of this result in enhanced use. A browser-based context is capable of the integration in a seamless and powerful manner, but faces significant exhibitions is data transfer and commension which must be integration in a seamless and powerful manner, but faces significant challenges related to data transfer and compression which must be overcome. This namer mesons an ambiention designed to hand sea challenges related to data transfer and compression which must be nower of a lybrid web context while attempting to overcome of a lybrid web context while attempting to overcome of the nower of a lybrid web context while attempting to overcome of the nower of a lybrid web context while attempting to overcome of the nower of a lybrid web context while attempting to overcome of the nower of a lybrid web context while attempting to overcome of the nower of a lybrid web context while attempting to overcome of the nower of a lybrid web context while attempting to overcome of the now of the no Overcome. This paper presents an application designed to hances the power of a hybrid web context while attempting to overcome commonworks for the distinutions of data transfer limitations and rem the power of a hybrid web context while attempting to overcome of a hybrid web context while attempting to overcome of data transfer limitations and removed from three multicly available.

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single main camera of the recent past, a modern production set with make use of multinle witness cameras. 3D laser scameras, spherous single main camera of the recent past, a modern production set with make use of multiple witness cameras, 3D laser scameras, spheron or RGBD cameras, aimine at eatherine as much data as movies data in make use of multiple witness cameras, 3D laser scameras, spheres, and a supervision or RGBD cameras, aiming a gathering as much data as possible regarding the surrounding environment, and facilitated by larger and or RGBD cancers, siming at gathering as much data as possible co-garding the surrounding environment, and facilitated by larger and cheaner storage devices. The traditional barriers between ornduc. garding the surrounding environment, and facilitated by larger and cheaper storage devices. The traditional barriers between produc-tion ones and roots northering are being broken. The large and cheaper storage devices. The traditional barriers between pools ton, pre- and post-production are being broken. The large apools of data from different sources has to be understood especially in tion, pre- and post-production are being broken. The large amount of data from different sources has to be understood, especially in terms of its anality and anishility. and has to be integrated in the of data from different sources has to be understood, especially in terms of its quality and satiability, and has to be integrated in the A standard approach to use this data is to view and analyse each anotative senarately, as part of the non-orotogening measure those A standard approach to use this data is to view and analyse cach modality separately, as part of the post-production process. How ever, this approach suffers from several applears: the process block modulity separately, as part of the post-production process. How ever, this approach suffers from several problems: the process false blace largely away from the moduction environment, the process false

compensate for the difficulties of data transfer limitations and the derive power. Results are presented from three, publicly available to data recorded on three publicly available. dering Power, Results are presented from three, publicly available test datasets, which represent a realistic sample of data recorded on a twnical high-budget orreduction set. CR Categories: 1.3.7 [Conputer Graphics]: Three-Dimensional Graphics and Realism-Virtual reality: D.2.13 [Software Environment CR Categories: 1.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Virtual reality: D.2.13 [Software-Dimensional ine]: Reusable Software-Reusable libraries: Keywards: WebGil, Pointelouds, Big Data, Web, Hybrid, Visual. 1 Introduction Cinema and television production are becoming increasingly digi-tal and data sourced from various modalities are now an integral Cinema and television production are becoming increasingly digit tal, and data sourced from various modalities are now an integral lat, and data sourced from various modalities are now an integr-Part of the production stages. Beyond the footage coming from

eter, this approach suffers from several problems: the process takes place largely away from the production environment: users must be present in the same location as where the data is now-ically shored. Place largely away from the production environment: users must be and view of the same location as where the data is physically sitted of and view of wordshift in individually sitted. Present in the same location as where the data is physically stored and viewing each modality individually is a process requiring the use of senarate antiware for each modality, which makes it difficult and viewing each modality individually is a process requiring the use of separate software for each modality, which makes in difficult for users to anderstand the integrated picture, and slows the whole the of separate software for each modality, which makes it difficult for users to understand the integrated picture, and slows the under process down. Addressing these issues is the primary motivation for users to understand the integrated picture, and slows the whole process down. Addressing these issues is the primary motivation for the work in this naper. We present a web-based visualisation application which allows re-We present a web-based visualisation application which also note users to access the production data recorded on-so more users to access the production data recorded in and possibilities for remote collaboration in the second of t ing new possibilities for remote contactoration and post-production process. The hybrid in: tightly integrating video, static imcate with traditional (Gonzales a

Hybrid Visualisation of Digital Production Big Data

Alun Evans* Department of Information and Communications Tochnologies Traisonesirat Demonstrations Rearies Anna Control Description

Our Approach?

Social Street View

Social Street View

An immersive social media navigation system in mixed-reality!

Demonstration

City Politi

The Augmentarium, UMIACS 6000 x 3000 pixels

Natural Immersive Virtual Reality?

almost never in a natural immersive virtual reality settings.

Conception, architecting & implementation



A mixed reality system that can depict geo-tagged social media in immersive 3D web environments

Blending multiple modalities of



Street View + Social Media

Depth maps, normal maps, and road orientation GPS coordinates and time creation

Enhancing visual augmentation



Maximal Poisson-disk sampling

Evaluated by image saliency metrics

Achieving cross-platform compatibility by



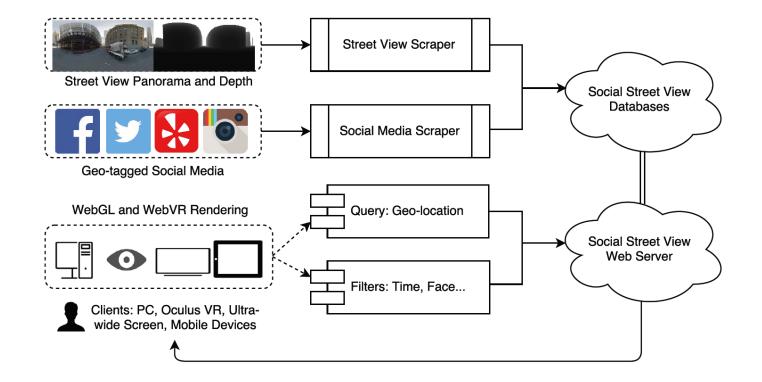
smartphones, tablets, desktop, high-resolution large-area wide field of view tiled display walls, as well as head-mounted displays.

Technical Challenges?

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System Overview

Architecture Social Street View System Flowchar





Street View Cars - Cameras, Lasers and GPS

Image courtesy from Google Street View



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image courtesy: Google

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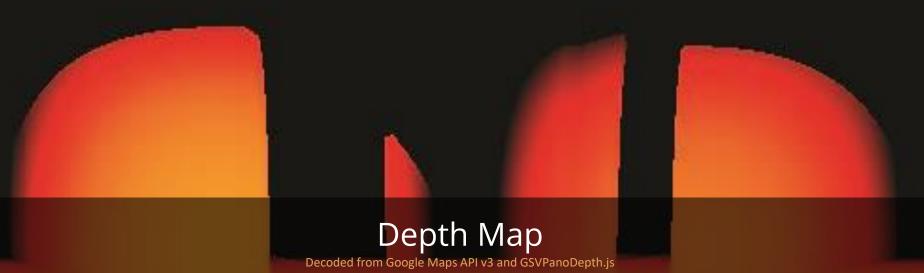
image courtesy: Google



Panorama

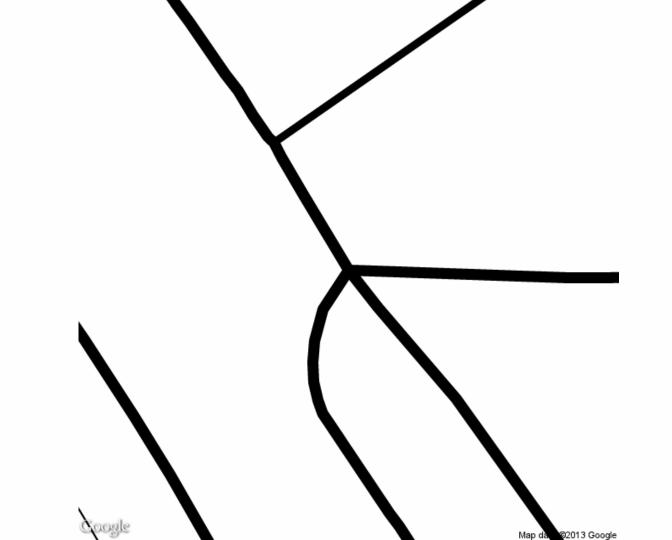
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Normal Map Decoded from Google Maps API v3



Road Orientations Decoded from Google Maps API v3

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image courtesy: Instagram

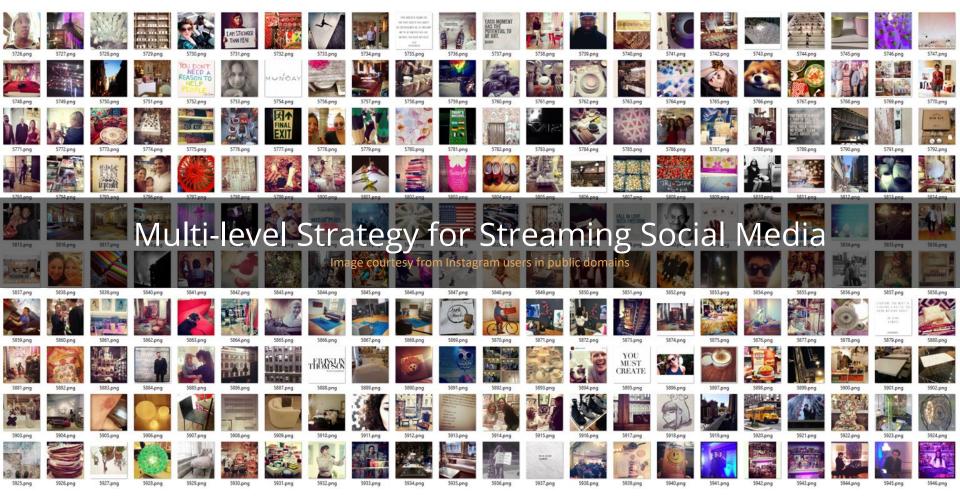
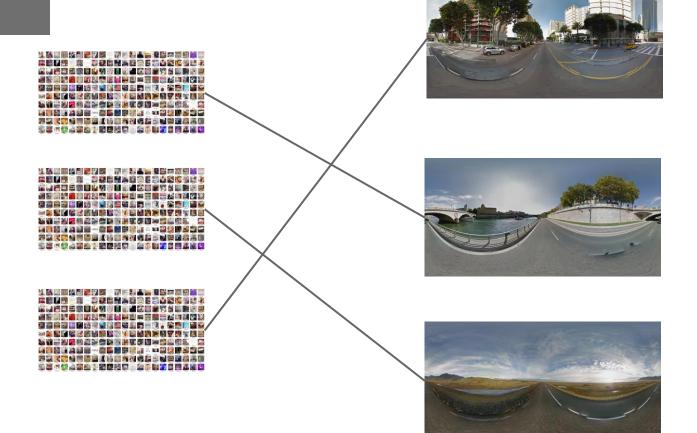


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Haversine Formula Andrew, 1805

$$\alpha_{ij} = \sin^2\left(\frac{\varphi_i - \varphi_j}{2}\right) + \cos\varphi_i \cdot \varphi_j \cdot \sin^2\left(\frac{\lambda_i - \lambda_j}{2}\right)$$

$$\beta_{ij} = 2 \cdot atan2(\sqrt{\alpha_{ij}}, \sqrt{(1 - \alpha_{ij})})$$

$$d_{ij} = R \cdot \beta_{ij}$$

Interface



Algorithm

Adding depth & normal map & maximal Poisson-disk sampling

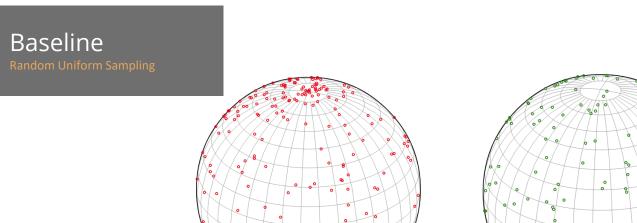
RESTAURANT 🏽 JUSHIDEN

Social Street View enables users to see-through the nearby restaurants.

Plt.

W/ K

Japanese Classic #sweets #dessert #nyc #datenight € ☐ Instagram ♥ 9 ■ 1 0 0010 2014-04-26 0916:41 € 40.759983416-73 982569143 @m away) × 4128' />



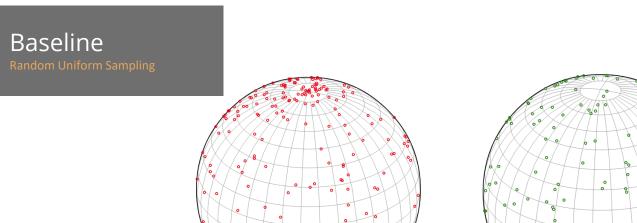
$$\varphi_i = (u_i - \frac{1}{2})\pi, \ \lambda_i = (2v_i - 1)\pi$$

 $x_i = \cos \varphi_i \cos \lambda_i, \ y_i = \sin \varphi_i, \ z_i = \cos \varphi_i \sin \lambda_i$

Without uniform sampling Accumulation

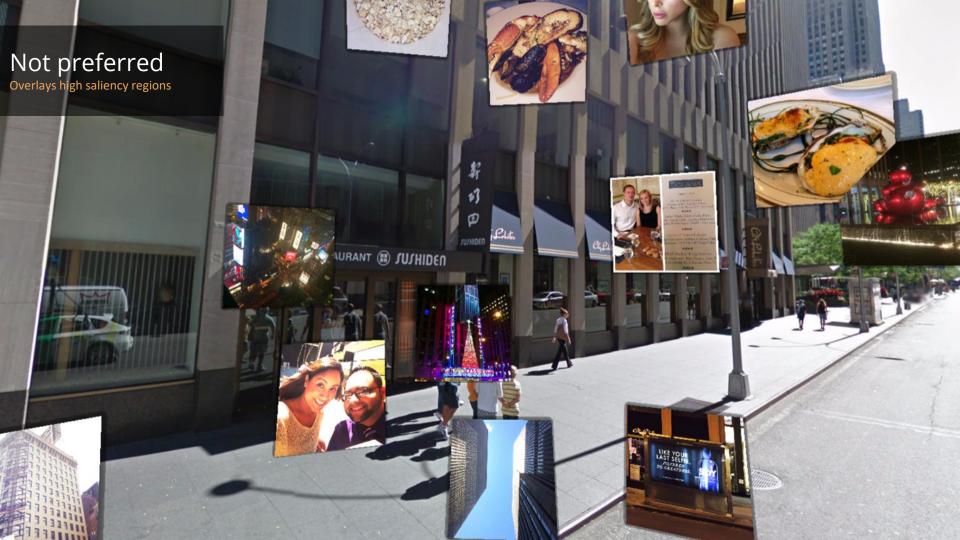
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$$\varphi_i = (u_i - \frac{1}{2})\pi, \ \lambda_i = (2v_i - 1)\pi$$

 $x_i = \cos \varphi_i \cos \lambda_i, \ y_i = \sin \varphi_i, \ z_i = \cos \varphi_i \sin \lambda_i$



Add depth map Remove sky and ground (most)

$\Omega_{s} = \{q_{i} \mid \forall q_{i} \in \Omega \land d_{i} = \infty\}$ $\forall \tilde{p}_{i} \in T, D_{min} < \tilde{d}_{i} < D_{max}$





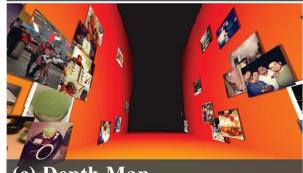
Can we ensure each image aligns with the building geometries?



$\Omega_g = \{q_i \mid \forall q_i \in \Omega \land \|\mathbf{n}_i - \mathbf{n}_g\| < \delta\}$

(a) Before Applying Normal Maps

(b) After Applying Normal Maps



(c) Depth Map



Justin

(d) Normal Map



(e) Depth+Normal Map

Can we reduce visual clutter and occlusion?

Maximal Poisson-disk Sampling Gamito et al. Remove visual clutter and occlusion

$$\forall \tilde{p}_i \in \tilde{P}, \tilde{P} \subseteq T, \forall S \subseteq \Omega : Pr(\tilde{q}_i \in S) = \int_S di$$

$$\forall \tilde{p}_i, \tilde{p}_j \in \tilde{P}, \tilde{p}_i \neq \tilde{p}_j : \|p_i - p_j\| \ge r$$

$$S(X) = \{ \tilde{p}_j \in T : \|\tilde{p}_i - \tilde{p}_j\| \ge r, \tilde{p}_i \in \tilde{P} \} : S(X) = \emptyset$$

$$(10)$$

Dart-throwing Algorithm PixelPie by Ip et al. using vertex and fragment shaders

image courtesy: DatarDana

Algorithm 1 Maximal Poisson-disk sampling by dart-throwing

Input: The minimum distance *r* between sampled points **Output:** A set \tilde{P} of points which satisfy equation (10)-(12)

1: Set
$$\tilde{P} \leftarrow \emptyset$$
, empty region $\tilde{R} \leftarrow T$

- 2: repeat
- 3: Generate some random points $\tilde{P}' \subseteq R$ by rasterizing them as circular disks into a depth map in vertex shader.
- 4: Remove any point $\tilde{p} \in \tilde{P}'$ whose corresponding point \tilde{q} violates $\tilde{q} \in \Omega_g \lor D_{min} < \tilde{d} < D_{max}$
- 5: Identify and remove the occluded disks from \tilde{P} by reading the depth map in the shader.
- 6: $\tilde{P} \leftarrow \tilde{P} \cup \tilde{P}'$
- 7: Update the empty region R in the fragment shader.
- 8: **until** $R \leftarrow \emptyset$

Project Social Media Pictures

By Maximal Poisson-disc Sampling

ALGORITHM 1: Social Media Layout using Poisson-disk Samples

Input: N sorted social media images $\hat{S} = \{s_i \mid i = 1 \dots N\}$, acquired from SSV servers.

Output: A set of image planes to display social media: $I = I_1 \dots I_M$, $M \leq N$. Generate the set of candidate sample points $\tilde{\mathbf{P}}$ by the PixelPie algorithm;

Sort points in $\tilde{\mathbf{P}}$ in descending order according to their corresponding values in the depth map D so that the closest sample point is laid out first;

Set $I \leftarrow \emptyset$;

for $i \leftarrow 1 \dots \min(N, |\tilde{P}|)$ do

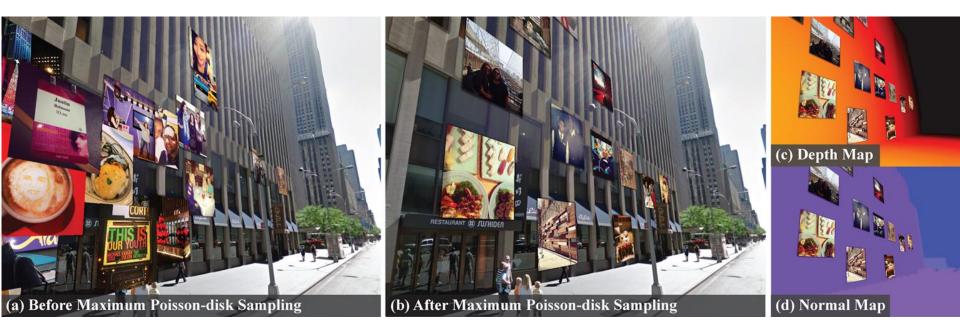
Place I_i with texture from $s_i \in \hat{S}$ at the projected position $\tilde{\mathbf{q}}_i \leftarrow \mathscr{P}(\tilde{\mathbf{p}}_i)$; Rescale I_i according to the corresponding depth value: $\tau_i \leftarrow \tau/d_i$ for perspective visual effects;

Rotate I_i so that it is perpendicular to the normal vector $\mathbf{n_i} \leftarrow \mathbf{N}(u_i, v_i)$; Add I_i to the result set: $I \leftarrow I \cup I_i$;

end



Remove visual clutter and occlusion



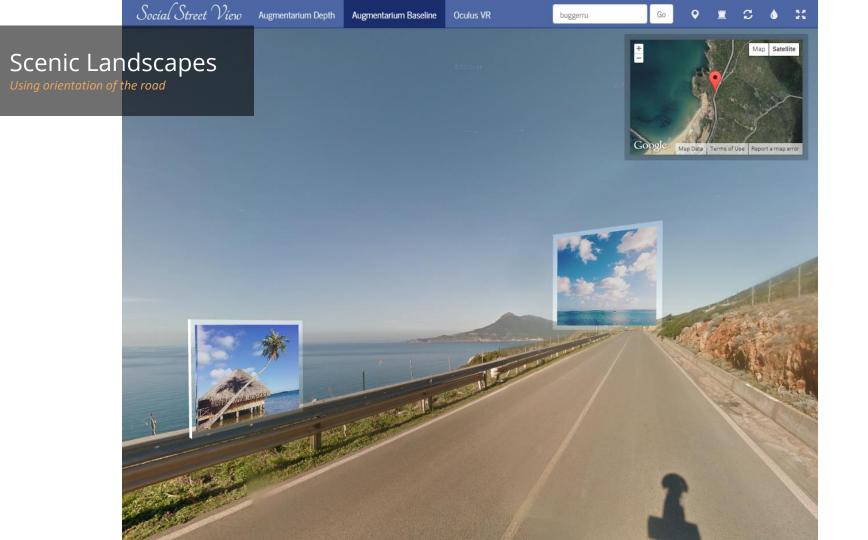
Scenic Landscapes

Using orientation of the road

ALGORITHM 2: Social Media Layout using Road Orientations

Input: |O| road orientations with $o_i \in [0, 2\pi]$. K social media to be placed for each orientation. Typically, |O| = 2 for a road with two orientations. **Output:** A set of image planes to display social media: $I = I_1 \dots I_M, M \ge K \cdot |O|.$ Set $I \leftarrow \emptyset$: for $i \leftarrow 1 \dots |O|$ do Set the position $\mathbf{q_i} \leftarrow (KR \cos o_i, h, KR \sin o_i)$ at height h and radius R: (Optional based on user's preference) Add a frontal image plane to I at q_i ; Set the translation $\mathbf{t} \leftarrow (T\cos(o_i + \frac{\pi}{2}), 0, T\sin(o_i + \frac{\pi}{2}))$ with constant T: for $k \leftarrow 1 \dots K$ do Set $\tilde{\mathbf{q}} \leftarrow (kR \cos o_i, h, kR \sin o_i);$ Add a left side image plane to I at position $\mathbf{q}' \leftarrow \mathbf{\tilde{q}} + \mathbf{t}$; Add a right side image plane to I at position $\mathbf{q}' \leftarrow \mathbf{\tilde{q}} - \mathbf{t}$; end

end



Scenic Landscapes

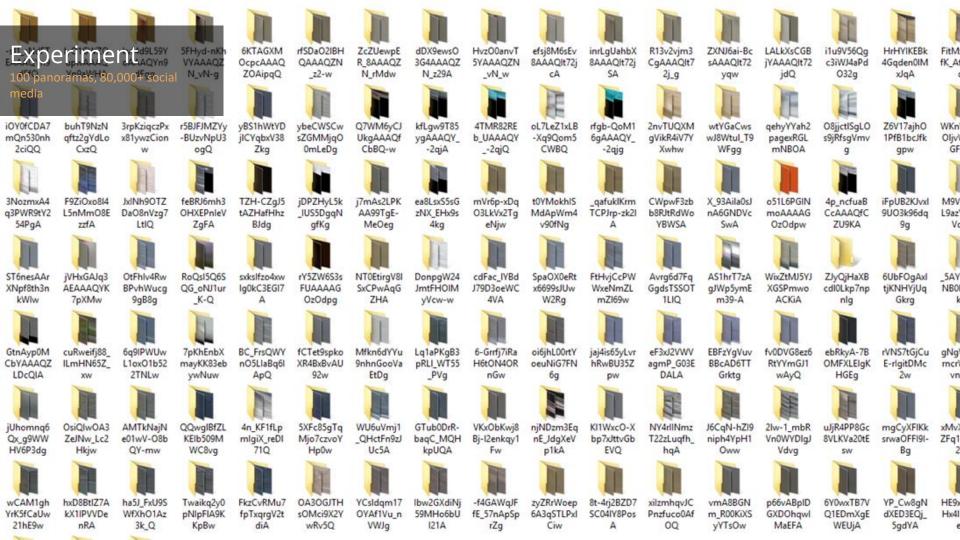
Algorithm

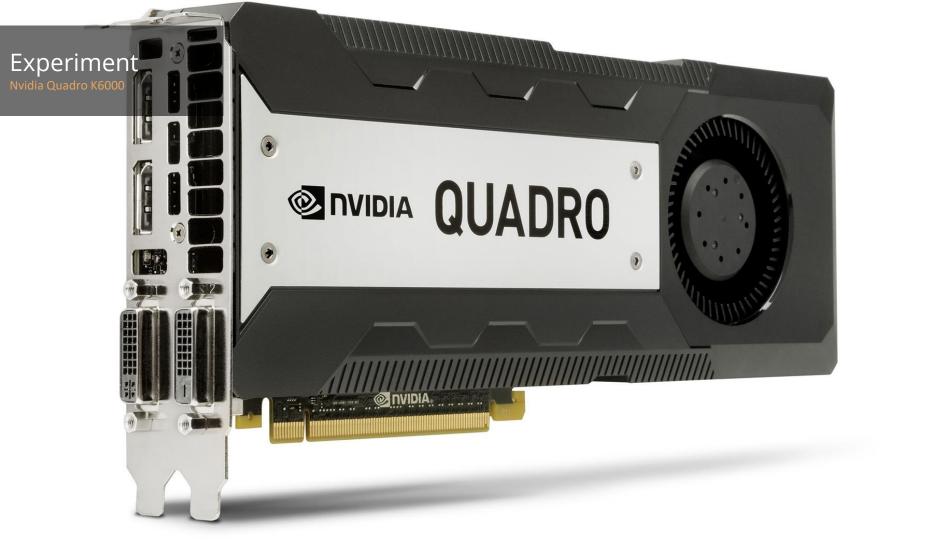
Adding depth & normal map & maximal Poisson-disk sampling

RESTAURANT 🗃 SUSHIDEN

In addition, our system allows users to walk around and explore live social media streams.

Lit.





Experiment Conditions of panoramic images

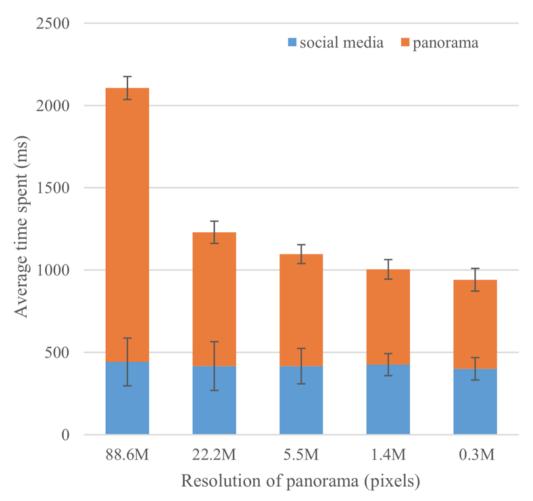
Pixels	Resolution	Number of tiles	File size
88.6M	13312×6656	26×13	$\sim 5M$
22.2M	6656×3328	13×7	$\sim 2M$
5.5M	3328×1664	7×4	$\sim 800 K$
1.4 M	1664 × 832	4×2	$\sim 300K$
0.3M	832 × 416	$\sim 2 \times 1$	$\sim 90K$

Common Consumer-level Displays

Initialization Time

Panorama takes a while to load

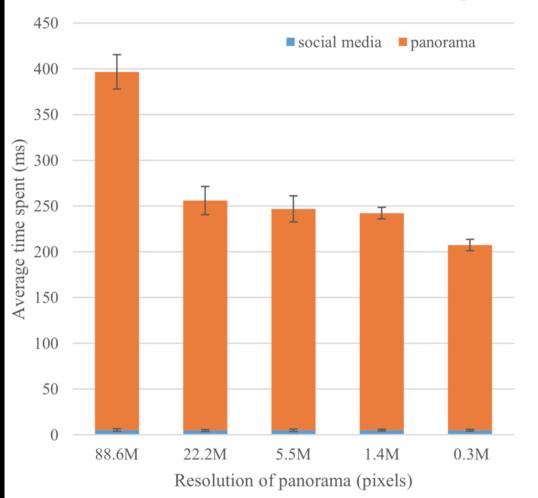
Initialization Time Based on Resolution



After Prefetching

¾ - ⅍ time reduced

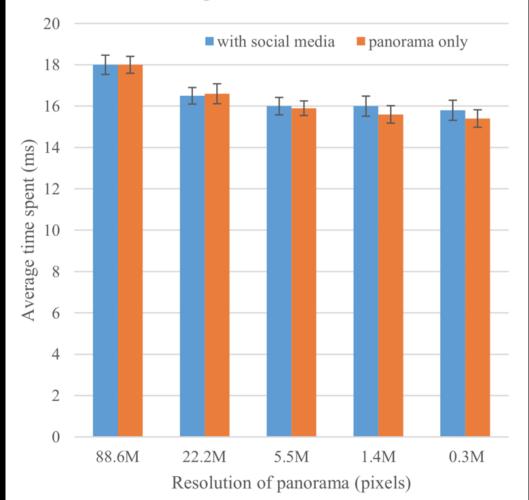
Initialization Time After Prefetching



Rendering Time

Almost 58~60 FPS

Rendering Time Based on Resolution

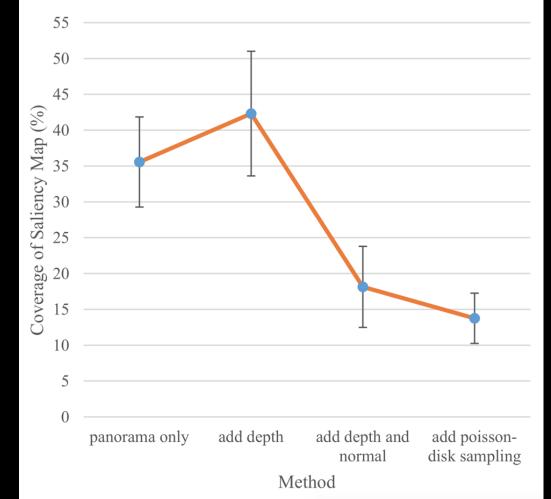




Elt.

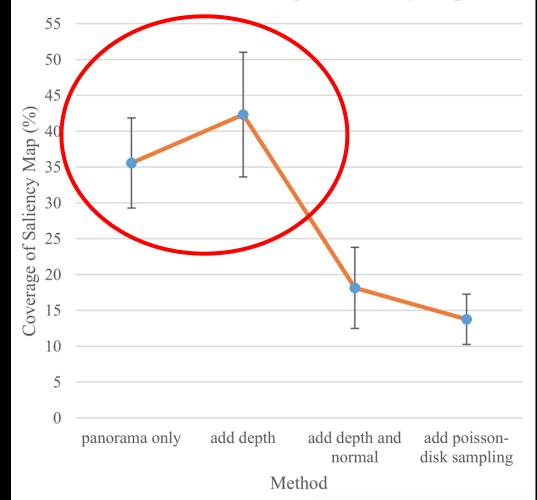
Social Media Coverage 100 panoramas for each algorithm

Social Media Coverage of Saliency Map



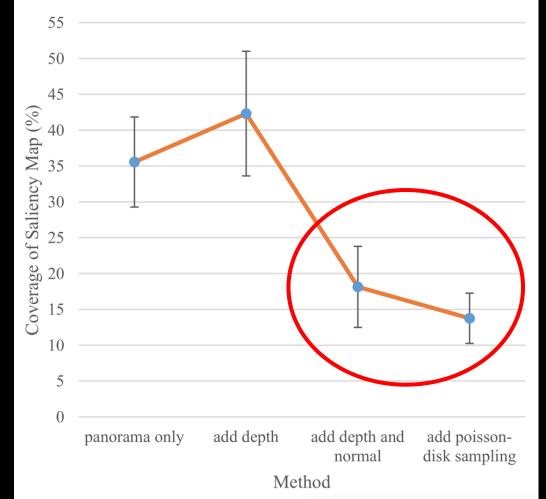
Social Media Coverage 100 panoramas for each algorithm

Social Media Coverage of Saliency Map



Social Media Coverage 100 panoramas for each algorithm

Social Media Coverage of Saliency Map



Potential Applications?



"

Stuck in traffic on our way to Cabo with this awesome view

#roadtrip #cabo #view #mexico

Daniela on *Instagram* July 12, 2014





Immersive story telling



However, we can hardly enjoy the view given the small posted image.

Business Advertising Museum, restaurant, real-estate ...

... dinner started off with amazing oysters paired with my favorite Ruinart blanc de blancs champagne

> By frankiextah on Instagram

Business Advertising

Gespril de Paris Stau 29 rue de Rivoli.

216,3251

Museum, restaurant ...



Crowd-sourced Tourism

Crowd-sourced Tourism

What if ... Temporal information is used for filtering and rendering?



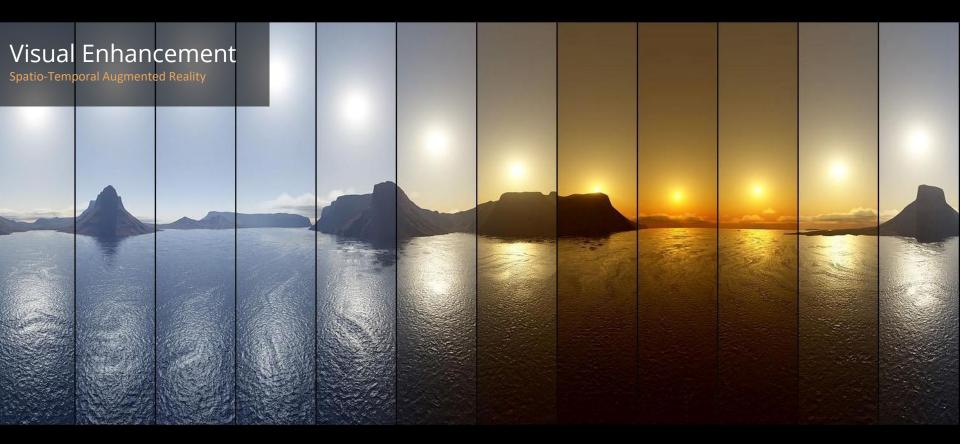
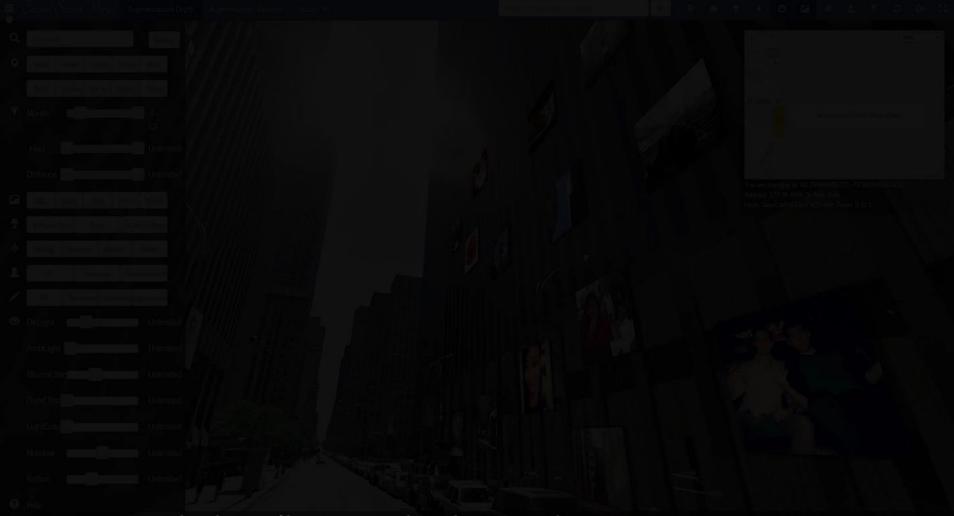


image courtesy: webneel.com



Users can use temporal or distance filters to narrow down their interested queries.

Seasonal Effect

Seasonal Effect

Seasonal Effect

Seasonal Effect

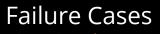
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red.

-

de Paris o rue de Rivoli. WE UP LIKE HUS

Autumn in Paris



A Square in London



Future Work

Digital City by 3D Reconstruction, Depth Fusion and Augmented Reality

image courtesy: wallpapervortex.com

Future Work Incorperate with Open3D in Web3D 2016?

image courtesy: Lu et al.

1 M







Acknowledgement

UMIACS **University of Maryland** Institute for Advanced **Computer Studies**

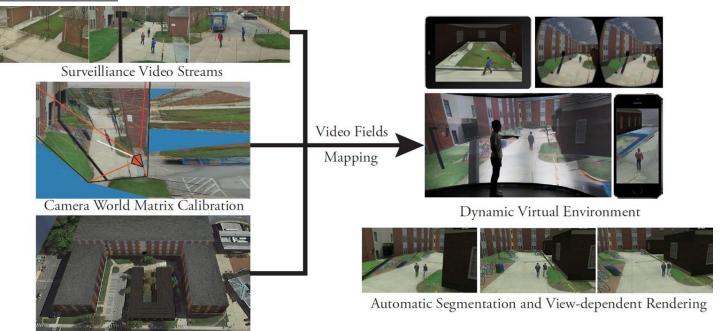




COMPUTER







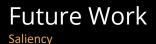
Static 3D Models and Satellite Image

Social Street View www.SocialStreetView.com Thank you! Any questions or comments are welcome!

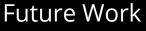
Ruofei Du and Amitabh Varshney Augmentarium Lab | GVIL | UMIACS Web3D 2016



Social Street View Backup Slides



- Low-level image saliency for layout
- Real-time or post-processed saliency maps



User Study

- High-resolution large-area screens
- Head-mounted displays



- Real-time geometric fusion
- HoloLens



- What is the (experimentally-justifiable) motivation for putting generic images into scenes?
- What is the relevance of which photos are displayed? And how this affects the worth?
- Whether it is possible to try and improve this relevance using vision techniques?

What is ignored in current social media sites?