Recommendations and **Previews** for Browsing Visualization Collections

Michael Oppermann

In collaboration with



UNIVERSITY THE **OF BRITISH COLUMBIA**



Robert Kincaid

Tamara Munzner







Tableau workbooks





United States \$145B	China \$38B		Hong Kong SAR,	Egypt, Arab	
			China \$20B	South Africa	
	Macao SAR, China	Korea, Rep.	India \$11B		
		\$12B			
Canada	Malaysia				
\$17B	\$14B		l		
Mexico	Japan				
	United States \$145B	United States China \$145B China \$38B Macao SAR, Macao SAR, China Canada Malaysia \$17B Malaysia Mexico Japan	United States \$145B \$38B Macao SAR, China Macao SAR, China \$17B Mexico Malaysia \$14B Japan Japan	United States SAR, SAR, China \$38B SAR, China SAR, China SAR, China Macao SAR, China Korea, Rep. \$12B SAR China Macao SAR, China SAR SAR SAR Macao SAR, China SAR SAR SAR Macao SAR, China SAR SAR SAR SAR SAR Macao SAR SAR SAR SAR <tr< td=""><td>United States Shina Hong Egypt, \$145B \$38B Hong SAR, South \$20B Macao SAR, Korea, India South Macao SAR, China Papan India India Malaysia 14B India India India Macao SAR, Japan India India India Image: Sar structure Japan Image: Sar structure Image: Sar structure</td></tr<>	United States Shina Hong Egypt, \$145B \$38B Hong SAR, South \$20B Macao SAR, Korea, India South Macao SAR, China Papan India India Malaysia 14B India India India Macao SAR, Japan India India India Image: Sar structure Japan Image: Sar structure Image: Sar structure



























Purchases





























































































Users have difficulty discovering relevant content.

Users often start from scratch instead of reusing content.



Agenda

1. Content-based recommendations

2. Representative previews (result snippets)

- 1. M. Oppermann, R. Kincaid, and T. Munzner: "VizCommender: Computing Text-Based Similarity in Visualization Repositories for Content-Based Recommendations." IEEE Trans. on Visualization and Computer Graphics (TVCG), 27(2): 495-505, 2021
- 2. M. Oppermann and T. Munzner: "VizSnippets: Compressing Visualization Bundles Into Representative Previews for Browsing Visualization Collections" [under review]



Recommendation systems are increasingly used to assist users by surfacing relevant content.



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Visual encoding recommendation Tableau ShowMe, Voyager, Draco, Data2Vis, ...

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Tableau ShowMe, Voyager, Draco, Data2Vis, ...

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VZZ	m mm	~~~
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Visualization workbook recommendations based on content features



Content-based filtering

Collaborative filtering



Content-based filtering

- Focus of our work
- Finding relevant items based on their actual content
- Less diverse but more accurate recommendations
- Allows identification of near-duplicate items

Collaborative filtering

Content-based filtering

Collaborative filtering

- Recommendations based on user interactions
- Requires no domain knowledge, allows fast computation, serendipitous recommendations
- Cold start problem for new items or new users

Content-based filtering

Collaborative filtering

Hybrid system



Content-based filtering Collaborative filtering

Hybrid system

Which content features are most informative for comparisons?

What techniques can we use for comparing and ranking viz specifications?



Text-based similarity measure

- Content-based recommendations
- Facilitate information seeking







Process

Close collaboration with the Recommender Systems Group at Tableau



Process

Close collaboration with the Recommender Systems Group at Tableau

VizCommender

- Extract content from viz specifications
- Analysis & feature engineering
- Proof-of-concept interface



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- Analysis & feature engineering
- Proof-of-concept interface

User study: Crowdsourced human text similarity judgements

Comparative model analysis



VizCommender

Search



Seattle Crime

caitlin.streamer • 2018-04-09

HCDE 210

arwa.mohammed6769 • 2016-11-23 ashish.khanal • 2018-03-11



Seattle Bike Racks

hekma • 2017-02-28



Metro latauya • 2016-01-21



urbana_crimes



LVO Crime Area Comparison

andrew1738 • 2018-05-21



PSA Findings by Year

kevin4543 • 2017-12-15



terrorism overview

olivier2575 • 2018-11-08



Bunch of Seattle Criminal

blair3220 • 2018-04-03

Reported Cyber Crime

vishu.rahar • 2018-04-03

Sort by relevance 👻



VizCommender prototype

megan2618 • 2018-06-07

ATL Crime



Incident-based Crimes in heather.keary • 2017-12-01



#BLESSEDLIT michael.valeri • 2018-04-03



Crime Rates per District

arwa.mohammed6769 • 2016-11-23



Data Visualization

danadaree • 2018-04-09



Urbana Crime Statistic

christoph.pressler • 2016-10-09



Number of Crimes in Each

arwa.mohammed6769 • 2016-11-23

Tableau visualization workbook







```
<worksheet name="Customer Analysis">
    <layout-options>
        <title>
            <formatted-text>
                <run>Sales and Profit by Customer</run>
            </formatted-text>
            </formatte
```





```
<worksheet name="Customer Analysis">
    <layout-options>
        <title>
            <formatted-text>
                <run>Sales and Profit by Customer</run>
            </formatted-text>
            </title>
        </layout-options>

        <rows>...[sum:Profit:qk]</rows>
        <cols>...[sum:Sales:qk]</cols>

        ...
</worksheet>
```





City	Customer Name	Sales	Discount	• • •

```
<worksheet name="Customer Analysis">
    <layout-options>
        <title>
            <formatted-text>
                <run>Sales and Profit by Customer</run>
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            </title>
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        <rows>...[sum:Profit:qk]</rows>
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        ...
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City	Customer Name	Sales	Discount	• • •

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<worksheet name="Customer Analysis">
    <layout-options>
        <title>
            <formatted-text>
                <run><mark>Sales and Profit by Customer</mark></run>
            </formatted-text>
        </title>
    </layout-options>
    <rows>...[sum:Profit:qk]</rows>
        <cols>...[sum:Sales:qk]</cols>
    . . .
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<datasource>
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            . . .
        </metadata-record>
        <metadata-record class="column">
            <remote-name>Customer Name</remote-name>
            . . .
            <remote-name>Sales</remote-name>
```



Initial experiments

Extracted text

AARAA ARRAA WAR WAR AAR WARAA WARAAA WARAA WARAAA WARAAA WARAA WARAA WARAA WARAA WARAA WARAA WARAA WARAAAAAA

Visual encodings





Different data, same encoding

Governor WA Bryant Inslee





Different data, same encoding



Same data, different visual encodings







Leaving out visual encodings



Leaving out visual encodings

For design inspiration and learning

Need visual style



Leaving out visual encodings

For design inspiration and learning Need visual style

Our primary task: Information seeking

- Core enterprise task
- Subject matter of a workbook
- Do not need visual style (marks, colors, layout properties, ...)



Data challenges



Data challenges

Very limited text


Very limited text

Additional challenges:

Multi-sheet workbooks and nested visualizations





Very limited text

Additional challenges:

- Multi-sheet workbooks and nested visualizations
- Incomplete workbooks



Very limited text

Additional challenges:

- Multi-sheet workbooks and nested visualizations
- Incomplete workbooks
- Multiple versions



Very limited text

Additional challenges:

- Multi-sheet workbooks and nested visualizations
- Incomplete workbooks
- Multiple versions
- Out-of-vocabulary words



customer analysis sales profit discount commission segment ratio ranking count ship performance target furniture office home supplies city drilldown late early product category forecast order quantity target ...



41

customer analysis sales profit discount commission segment ratio ranking count ship performance target furniture office home supplies city drilldown late early product category forecast order quantity target ...

Transform?

Numeric document representation







customer analysis sales profit discount commission segment ratio ranking count ship performance target furniture office home supplies city drilldown late early product category forecast order quantity target ...

Transform?

Numeric document representation







analysis sales profit discount customer commission segment ratio ranking count ship performance target furniture office home supplies city drilldown late early product category forecast order quantity target ...

Transform?

Numeric document representation





NLP models

- TF-IDF & cosine similarity
- Latent semantic indexing (LSI) & cosine similarity
- Latent dirichlet allocation (LDA) & Jensen-Shannon divergence
- Word embeddings (Doc2Vec, GloVe) & cosine similarity



Overview

VizCommender

- Extract content from viz specifications
- Analysis & feature engineering
- Proof-of-concept interface

User study: Crowdsourced human text similarity judgements

Comparative model analysis





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Crowdsourced human similarity judgements



2-alternative forced choice experiment

135 Triplets





2-alternative forced choice experiment

135 Triplets



75 Participants





2-alternative forced choice experiment

135 Triplets



75 Participants



NLP models





51

Experimental stimulus

Progress	Co
Is A or B more s	imilar to the Reference ?
R	Reference
Sheet 1	
airplane safety AVG(Age) Sex Embarked	
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• A	ОВ
Flight incidents	National Parks
Q2 SUM(Survived) Sex	Sheet 7 Park Name AVG(Recreation Visitors)
pclass survived name sex age sibsp parch ticket fare cabin embarked boat body	Park Year Recreation Visitors Non-Recreation Visitors Park Name Park Type State



Experimental stimulus

Prog	ress		Continue
	Is A or B mor	re similar to the Reference ?	
		Reference	
Baseball St	ory Final		
Sheet 9 Height & Ba height AV	tting Average & Handedness G(avg) handedness		
name,handed	Iness,height,weight,avg,HR		
	Α	ОВ	
Final Visualization		Olympics 2016 - Which Athlete and Sport are you	
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Agreement scores

	LDA	TF-IDF	GloVe	Doc2Vec	LSI
TF-IDF	.978				
GloVe	.978	1			
Doc2Vec	.912	.889	.889		
LSI	.935	.956	.956	.848	
Human	.914	.892	.892	.871	.852



Agreement scores

	LDA	TF-IDF	GloVe	
TF-IDF	.978			
GloVe	.978	1		
Doc2Vec	.912	.889	.889	
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LSI	.935	.956	.956
Human	.914	.892	.892

- Very good alignment between human similarity judgements and off-the-shelf model predictions
- LDA performed slightly better







News article

Gov. Gavin Newsom declared a state of emergency Tuesday in response to wildfires in California, as the state gave evacuation orders and battled the effects of a sweltering heat wave, rolling blackouts and the coronavirus pandemic. By early Wednesday morning, the state fire authorities had ordered residents to evacuate in parts of Santa Cruz, San Mateo, Napa and Sonoma Counties, in Northern California, where thunderstorms brought lightning strikes this week. The largest fire in the region, called the SCU Lightning Complex, had spread to 35,000 acres in several counties east of San Jose and was 4 percent contained. Another fire, called the LNU Lightning Complex fire, was quickly growing north of the Bay Area, with 32,000 acres burned by about 9:30 Tuesday night.

That fire forced evacuations in parts of Napa and Sonoma, with the authorities warning of an "immediate threat to life" in some places. Local news outlets showed structures consumed by flames in Vacaville, about 35 miles southwest of Sacramento, and fire overtaking a camera meant to help spot wildfires on Mount Vaca. Photos and videos on social media showed flames lapping at the road and, in the hours before dawn, some images showed a glowing red sky, as the fire lit up dense smoke. To the south, residents in Oakland and San Francisco could smell smoke as they woke up on Wednesday morning. The authorities around Northern California warned of poor air quality in addition to the rising heat ...





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Extracted text from viz workbook

customer analysis sales profit discount commission segment ratio ranking count ship performance target furniture office home supplies city drilldown late early product category forecast order quantity ...



Proof-of-concept implementation





VizCommender

Search





Makeover Monday Week 23 mak.gill • 2017-06-05

Makeover Monday Week 23 frans.rasmussen7740 • 2017-06-08



Metcalfe Park safe.sound.mke • 2017-12-15



Grant's Nepalese Tourism hollidaygg • 2015-03-08



priyesh.singh + 2017-06-05



O.BUM

Grant's Nepalese Tourism3 hollidaygg • 2015-03-08



The National Parks Have N pablolgomez • 2017-06-05



MakeOver Monday TOTC 2017 nick.bignell • 2017-06-05





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ASBURY Dashboard

brian.jones3491 • 2018-02-09



Makeover Monday Week 23

esben.michelsen • 2017-06-05



Top National Parks in Ame

sarah.bartlett • 2017-06-05



Windermere

lester.nare • 2018-06-08



National Parks poojagandhi • 2017-06-05



MM Live nai.louza • 2017-06-05



Makeover Monday week 23

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Interactive workbook







MakeOver Monday TOTC 2017 nick.bignell



nick.strohecker



Related workbooks Similar data Similar versions

Similarity facets for different user tasks



Classification of Ozone Levels1 tihana



MakeOver Monday TOTC 2017 nick.bignell



Nick Twitter Report nick.strohecker











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Makeover Monday Week 2 - US Parks mak.gill	3 Makeover Mo priyesh.singh	onday week 23	National P Trends krupp	Park Growth	National Parks poojagandhi
Related workbooks	Similar data	Similar v	ersions		

ty facets for different user tasks

d workbooks





Makeover Monday Week 23 - The Popularity of US National Parks umar.hassan



Classification of Ozone Levels1 tihana



MakeOver Monday TOTC 2017 nick.bignell



nick.strohecker

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	Golden Gate Blue Ridge Pkwy Great Smoky Mounta Is George Washington ME
	 Similar
	Natchez Trace Pkwy
Top 20 park development over decades	Grand Canyon Similar
Top 20 park development over decades	Cape Co
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	National Reviews U. 104 National Reviews U. 104 National Monumetr 25,754 National Southers 19,704 National Southers 19,704 National Reviews 518 21,704 National Reviews 518 21,704 National Reviews 518 National Military Reviews 6,514 National Military Reviews 6,514 National Lakeshore 6,544 National Lakeshore 6,544
Makeover Monday Week 23 Makeover Monday Week 23 Ma - US Parks esben.michelsen priy mak.gill	keover Monday week 23 MMConference yesh.singh charlie.hutcheson

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National Park Growth Trends krupp



National Parks poojagandhi



Makeover Monday Week 23 - The Popularity of US National Parks umar.hassan

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MM Live nai.louza





Seattle crime







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Similarity facets for different user tasks

- Related workbooks
- Similar data
- Similar versions

66

Summary (VizCommender)

- Challenges for content-based visualization recommendations
- Design and implementation of a proof-of-concept pipeline
- Analysis of applicable NLP techniques

M. Oppermann, R. Kincaid, and T. Munzner: "VizCommender: Computing Text-Based Similarity in Visualization Repositories for Content-Based Recommendations." IEEE Trans. on Visualization and Computer Graphics (TVCG), 27(2): 495-505, 2021





The National Parks Have Never Been More Popular pablolgomez



MM Live nai.louza



National Parks USA neil.richards



National Parks poojagandhi







National Park Recreational Growth

curtis.harris



MakeOver Monday TOTC 2017 nick.bignell













Generalizable to other visualization platforms



Generalizable to other visualization platforms



Google Data Studio

iii plotly

 $\bullet \bullet \bullet$

Bl <u>SLooker</u>





Compressing visualization bundles into representative previews





Visualization bundles

workbooks, reports, looks, apps, ...





71

🖽 Density Plots / 9 of 9 🗸



🚱 By Yuri Vishnevsky 🛛 🜐 Published Jan 25 🖉 Apache 2.0

Strange Attractors

We can use a density plot to plot the orbit of a strange attractor.

The orbit is modeled as a JavaScript iterable and 10,000,000 orbit samples are rendered in batches using a sequential log color scale.



<u>observablehq.com</u>

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	< Prev Next >	
	😵 Fork 🗅 🗢	
% 1 fork ⊗ 4 files ⊞ 2 collections ♡ 40) likes	


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Olympics

viz Author: <u>Olympics</u> | Last Updated: Apr 26, 2017

	-		

Olympics

Olympics

viz Author: Christopher | Last Updated: Apr 27, 2020



Olympics

Olympics

viz Author: <u>Shardul</u> | Last Updated: Sep 24, 2020



Olympics

viz Author: <u>Prashanth Vulapu</u> | Last Updated: Mar 20, 2017



olympics

olympics

viz Author: manoj | Last Updated: Oct 30, 2014



Olympics

Olympics

viz Author: <u>Hariharan</u> | Last Updated: Mar 4, 2020



Olympics

Olympics

viz Author: <u>raja</u> | Last Updated: Apr 14, 2018

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How to compress visualization bundles into representative previews?

Visualization snippets







We present a computational pipeline for the generation of visualization snippets

Visualization snippets









Review snippets







Review snippets

Analyze bundles









Review snippets



Analyze bundles

Tableau product groups



Existing snippet designs







Challenges

images & text







Challenges

images & text



	Image: Additional and the second and the se	MEDAL MEDAL viz Author: <u>NILOFER SHAIKH</u> Last Updated: Dec 13, 2017
		Medal Medal viz Author: <u>Rita</u> Last Updated: Apr 1, 2015
-		/ledal /ledal viz Author: <u>nurfarrah aini</u> Last Updated: Feb 23, 2020
		nedal nedal viz Author: <u>Ratna P Wulandari</u> Last Updated: May 3, 2019



Extract content from collections



Select and rank bundle image content

Select and compress bundle text content

Assemble and lay out snippets



Extract content from collections

+ableau⁺+public

O Observable

Select and rank bundle image content

Select and compress bundle text content

Assemble and lay out snippets



Extract content from collections

Select and rank bundle image content

Select and compress bundle text content

Assemble and lay out snippets



Extract content from collections



Select and compress bundle text content

Select and rank bundle image content

Assemble and lay out snippets







Filter empty views





Filter views that are part of a dashboard





Filter similar views







Rank images

prioritize dashboards and unique chart types



_	
6	
in ica	88,872
anada	17,817
aribbean	34,571
entral	311,404
entral Asia	132,480
st	91,523
MEA	43,898
orth	194,598
orth Asia	165,578
ceania	120,089
outh	140,356
utheast Asia	17,852
est	108,418



Image selection and ranking



Image selection and ranking



D) Siamese CNN

Image selection and ranking





Visual inspectors

VizSnippets Inspector Image Colours			
Random sample C % Primary Color: Min	98.5 Max 100		
99.9%	100.0%	99.61%	100.0%
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	mapcountresponsesr4		
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VizSnippets Inspector Image Colours

Random sample 🖒

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67.41%





919

994

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497

71.09%



73.55%

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80.5

42.26%



58.99%

Work Location Distribution









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Boarding/Alighting Alighting	1
Day Type Weekday	
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Activity	643

City Coimbetore	
Count of Votes 1 to 5,473	
C2011	70

VizSnippets Inspector Label Image Similarity

Pair: 4787









VizSnippets Inspector Image Selection & Ranking Incomplete images (Max. dominant colour % -Embedded images Filter: 98.5) Diversify chart types Ranking: Diversification 0.75 Show chart types Show filtered images Compare rankings Size _____ 12 Display: **D** 71.94 76.86 **D** 75.9 82.42 D 73.18 D 79.36 97.6 78.47 80.08 84.13 D 58.23 **D** 42.59 **D** 99.9 93.89 **D** 89.28 91.27 91.28 90.77 Ser A Martine and the work 1111111111 93.8 96.46 97.39 **D** 91.52 **D** 70.62 49.42 53.25 **D** 60.24 D 66.1 72.29















Extract content from collections

Select and compress bundle text content

Select and rank bundle image content

Assemble and lay out snippets



Compress text content





Visual inspectors

VizSnippets Inspector Text Content

Data: ☑ Workbook title ☑ Date ☑ Us Derived: ☑ TF-IDF keywords ☑ TF-IDF keywords ☑ TF-IDF keywords Filter: ☑ □ □ □ □ □ □	ser 🗹 Visits 🔽 Dashboard name 🗹 Sho vords (incl. inactive data fields) 🗌 TF-IDF keywor	eet name 🛛 Sheet title 🗖 Active data fields rds (excl. inactive data fields)	Inactive data fields Other text
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Display: Enhance title Lemmatize keyw Redesign - Revised version 3 years ago neville.fernandes Visits: 11 firearm homicide territory rate states country developed death firearms compare ownership control child people rank pile gun suicides develop law Dashboard 1 Dashboard 2 Dashboard 3 Story 1 Sheet 2 SUM(Homicide by firearm rate per 100,000 pop) SUM(Rank by rate of ownership) Country/Territory Sheet 3 (2) States with no gun control law for children SUM(Firearms Homicide Rate per 100,000) States States SUM(Gun Measure Law) Sheet 3 (3) States with at least 1 gun control law for children SUM(Firearms Homicide Rate per 100,000) States States SUM(Gun Measure Law) Sheet 2 (2) But is bottom of the pile compared to developing countries SUM(Homicide by firearm rate per 100,000 pop) SUM(Rank by rate of ownership) Country/Territory Country/Territory Sheet 4 SUM(Firearm deaths - Total) SUM(Firearm deaths - Suicides) Year Sheet 1 Gun stats in US and other developed countries SUM(Average firearms 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Distance between keywords: Min 🔵

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0.14	genderid	gender
0.14	ethnicitykey	ethnicity
0.14	ton	tons
0.14	win	wins
0.14	polygonid	subpolygonid
0.14	countnonnull	countnull
0.14	weight	weighted
0.14	lot	lots
0.14	customer	custom
0.12	productid	product
0.12	retweeted	retweet
0.12	quarter	quarterly
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Extract content from collections



Select and compress bundle text content

Select and rank bundle image content

Assemble and lay out snippets



Top-down design framework






How many? How big?



How to display?





How to display?								
A) Grid	B) Strip	C) List	D) Table	E) Preview				





	How to display?	
	A) Grid B) Strip C) List D) Table E) Preview	
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Power BI





VizSnippets



Prosper - v1220201823h00 myriam3764 • 2 years ago • 121 views • loan client originate 2013 origination score recovery chargedoff yearly terms *



Power BI 2006 2007 2008 2010 2010 2011 2012 2013 2014 score in \$ originated loans 2011 ProsperRating (Alpha) AA B C D Prosper - v1220201823h00 myriam3764 凸 121



VizSnippets



Delays

irene.w1481 • 2 years ago • 5 views •

airline arrival departure scheduled taxi wheels unnamed airport iata elapsed tail

Power BI

Delays	
irene.w1481	凸 5



Summary (VizSnippets)

- Key challenges and a top-down design framework pertaining to visualization snippets
- A computational pipeline for the lossy compression of visualization bundles into snippets
- A methodology for extensive visual inspection through random sampling





The National Parks Have Never Been More Popular



MM Live nai.louza



National Park Recreationa Growth curtis.harr



MakeOver Monday TOTC 2017 nick.bignell

visitors in

National Parks USA neil.richards



National Parks poojagandhi











Recommendations and **Previews** for Browsing Visualization Collections

Michael Oppermann (michaeloppermann.com)

- M. Oppermann, R. Kincaid, and T. Munzner: "VizCommender: Computing Text-Based 1) Similarity in Visualization Repositories for Content-Based Recommendations." IEEE Trans. on Visualization and Computer Graphics (TVCG), 27(2): 495-505, 2021
- M. Oppermann and T. Munzner: "VizSnippets: Compressing Visualization Bundles Into 2) **Representative Previews for Browsing Visualization Collections**" [under review]

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