



ZJU-IDG

VAID: Indexing View Designs in Visual Analytics System



Lu Ying¹



Aoyu Wu²



Haotian Li³



Zikun Deng⁴



Ji Lan⁵



Jiang Wu¹



Yong Wang⁶



Huamin Qu³



Dazhen Deng¹



Yingcai Wu¹



1. State Key Lab of CAD & CG, Zhejiang University
2. Harvard University, Cambridge, Massachusetts, United States
3. The Hong Kong University of Science and Technology, Hong Kong SAR, China
4. South China University of Technology Guangzhou, Guangdong, China
5. AIFT, Hong Kong, China
6. Singapore Management University, Singapore

VAID Explorer

Query Panel A Filtering View

Filters

Task: Action Task: Target

Layout

Visualization

Visual Channel

Data Type

nominal, temporal

JSON Specification

Use Specification

```

"x": {
  "type": "*"
},
"y": {
  "type": "*"
}

```

Retrieved Visualizations: 46 found

left base tower right base tower

base

VAID: Indexing View Designs in Visual Analytics System

Query Panel

Retrieved Visualizations: 46 found

Filters

Task: Action Task: Target

Layout

Visual Channel

JSON Specification

Use Specification

SEARCH

RESET

Error Number: 1

high-level tactical actions

B Indexing View

SEARCH

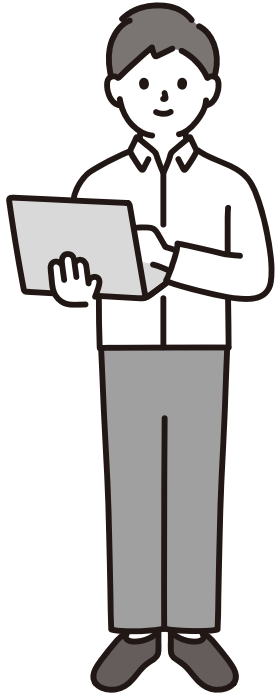
RESET

Hi, I am Lu Ying 🖐️

✉️ yingluu@zju.edu.cn

I am a Ph.D. of computer science at the State Key Lab of CAD&CG, Zhejiang University and a ZJUIDG member supervised by Prof. Yingcai Wu.

My research focuses on data storytelling, glyph-based visualization. My research is dedicated to integrating the AI technique into visualization to ease the creation of visualization.

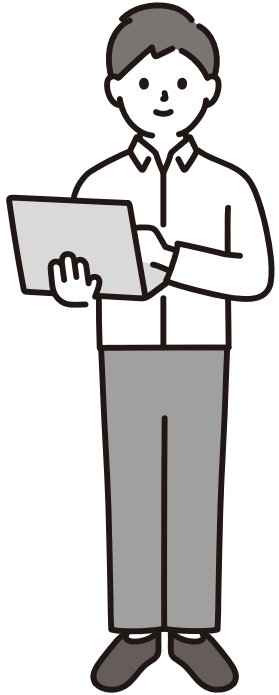


VA system
Designer

GAStech



**investigate employees'
potential private use of the
company cars.**



VA system
Designer

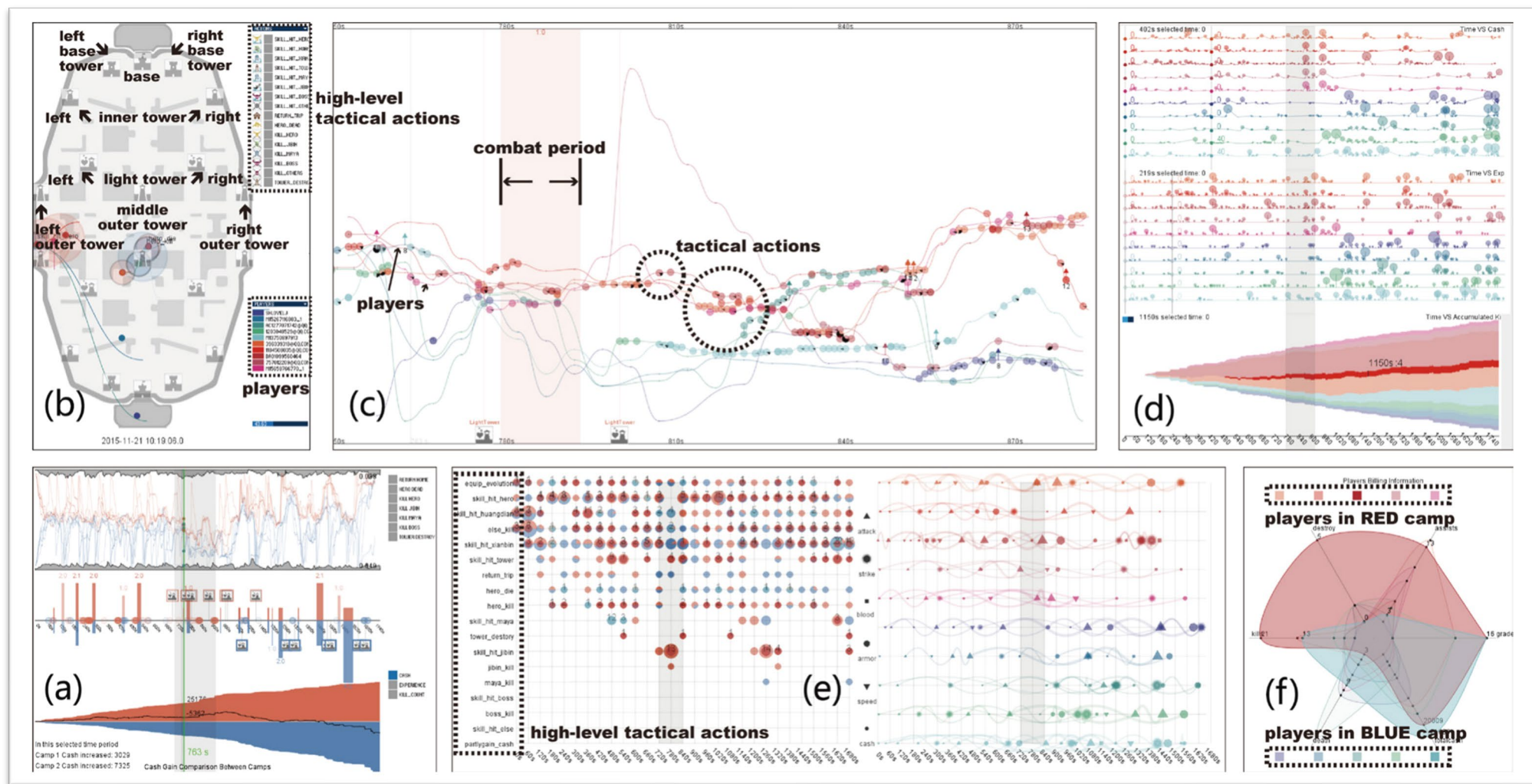
Visual Analytics (VA) System

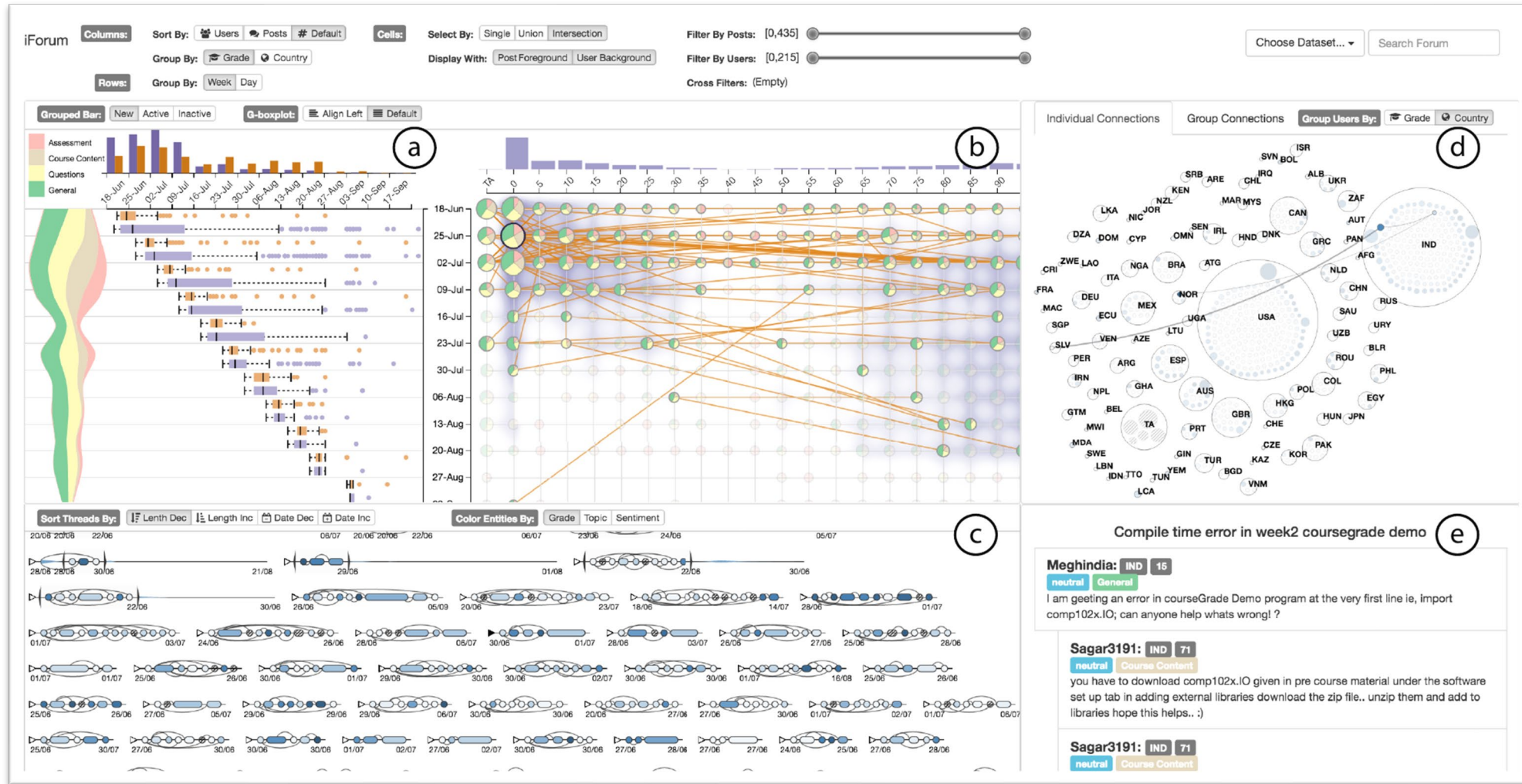
Visualization Interaction



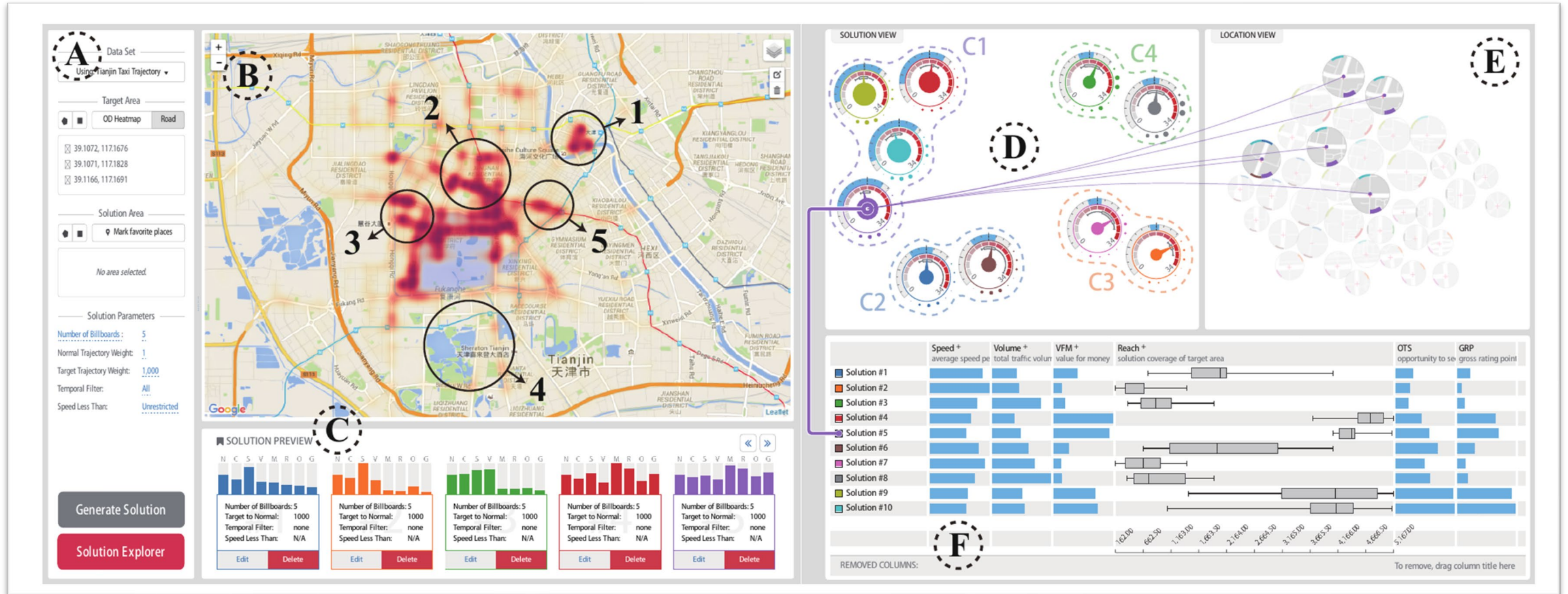
**Help experts
with data analysis process**

Li, Quan, et al. "A visual analytics approach for understanding reasons behind snowballing and comeback in moba games." IEEE transactions on visualization and computer graphics 23.1 (2016): 211-220.

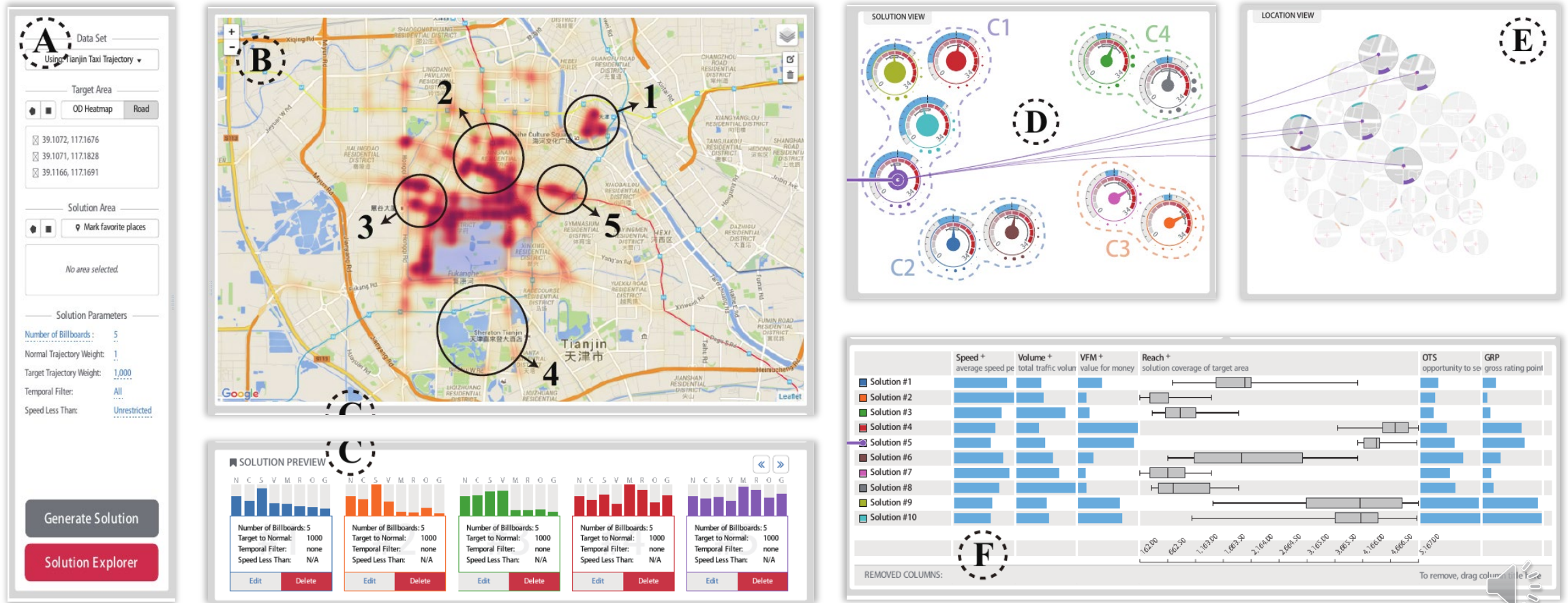


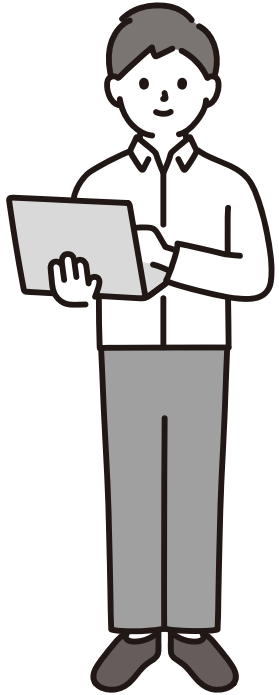


Liu, Dongyu, et al. "Smartadp: Visual analytics of large-scale taxi trajectories for selecting billboard locations." IEEE transactions on visualization and computer graphics 23.1 (2016): 1-10.



Liu, Dongyu, et al. "Smartadp: Visual analytics of large-scale taxi trajectories for selecting billboard locations." IEEE transactions on visualization and computer graphics 23.1 (2016): 1-10.

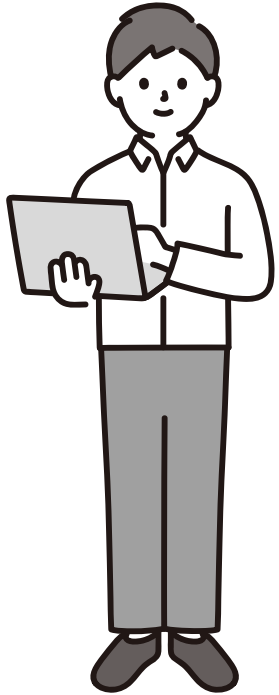




VA system designer

Search





VA system designer

Search

Google Scholar search results for "visual analytics system".

Articles About 1,280,000 results (0.11 sec)

Any time
Since 2024
Since 2023
Since 2020
Custom range...

Sort by relevance
Sort by date

Any type
Review articles

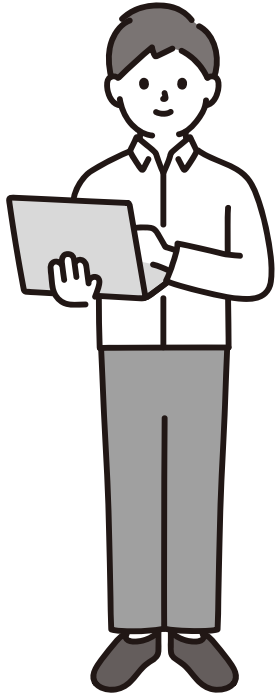
include patents
 include citations
 Create alert

VAIT: A visual analytics system for metropolitan transportation [PDF] [ieee.org](#)
[S Lju](#), [J Pu](#), [Q Luo](#), [H Qu](#), [LM Ni](#)... - IEEE Transactions on ..., 2013 - [ieeexplore.ieee.org](#)
... utilization and planning of the **system**. We report our experience in building the **Visual Analytics** for Intelligent Transportation (VAIT) **system**, which is the first **system** on real-life large-...

A visual analytics system for exploring, monitoring, and forecasting road traffic congestion [PDF] [ieee.org](#)
[C Lee](#), [Y Kim](#), [S Jin](#), [D Kim](#)... - IEEE transactions on ..., 2019 - [ieeexplore.ieee.org](#)
... In this paper, we present a **visual analytics system** to support analysts and reporters in the congestion management and traffic broadcast domains. We have conducted interviews with ...

Visual analytics: Definition, process, and challenges [PDF] [uni-konstanz.de](#)
[D Keim](#), [G Andrienko](#), [JD Fekete](#), [C G6rg](#)... - 2008 - Springer
... A theoretically founded evaluation framework needs to be developed which allows assessing the contribution of any **Visual Analytics system** toward the level of effectiveness and ...

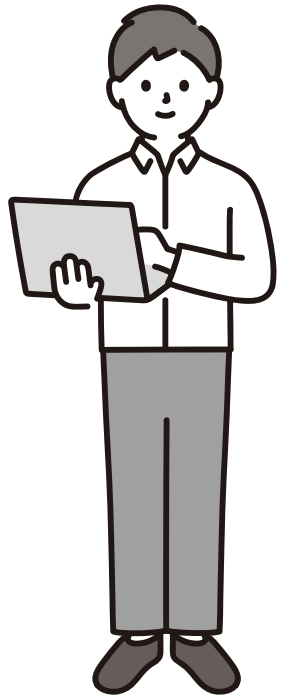




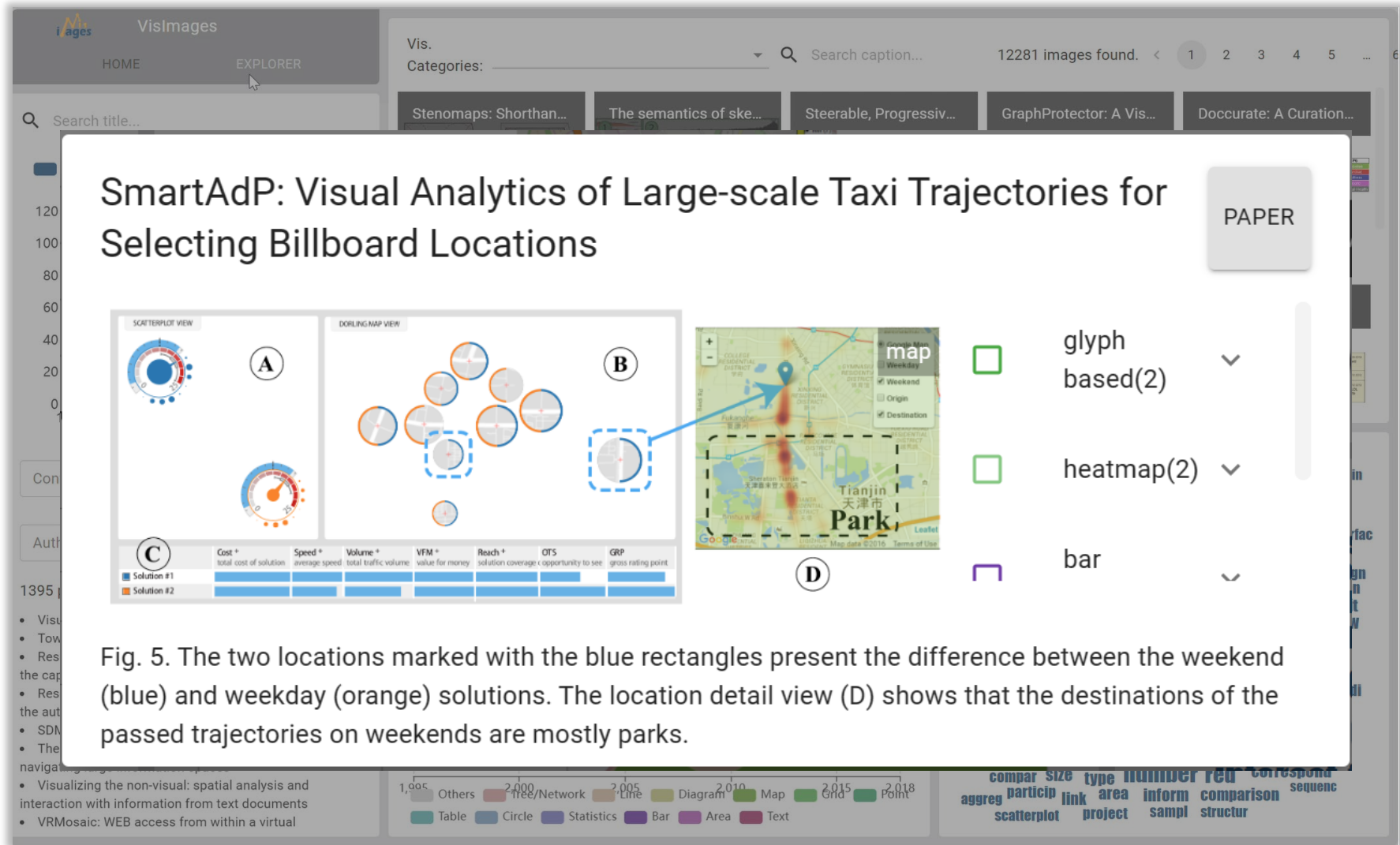
VA system designer

Search

The screenshot shows a Google Scholar search for "visual analytics system". The search bar at the top contains the text "visual analytics system" and a search icon. Below the search bar, it indicates "About 1,280,000 results (0.11 sec)". The results are listed in a table-like format with columns for article titles, authors, and PDF links. The first result is "VAIT: A visual analytics system for metropolitan transportation" by S. Liu, J. Pu, Q. Luo, H. Qu, L. M. Ni, et al., published in IEEE Transactions on Visualization and Computer Graphics in 2013. The second result is "A visual analytics system for exploring, monitoring, and forecasting road traffic congestion" by C. Lee, Y. Kim, S. Jin, D. Kim, et al., published in IEEE Transactions on Visualization and Computer Graphics in 2019. The third result is a book "Visual analytics: Definition, process, and challenges" edited by D. Keim, G. Andrienko, J. D. Fekete, and C. Görg, published by Springer in 2008. The fourth result is "iVisClassifier: An interactive visual analytics system for classification based on supervised dimension reduction" by J. Choo, H. Lee, J. Kihm, H. Park, et al., published in the Symposium on Visual Analytics in 2010. Below the main results, there is a "Related searches" section with terms like "interactive visual analytics system", "visual analytics system exploration", "visual analytics system domain experts", "visual analytics system real estate data", "present an interactive visual analytics system", "visual analytics system design and develop", "visual analytics system visualizations", and "visual analytics system help users". At the bottom, there is a partial result for "A visual analytics system for multi-model comparison on clinical data" from sciencedirect.com.



VA system designer



VAID

VA system's ID



VAID

View Designs



Task

Data

Visualization



Query Panel

Filters

Task: Action ▼ Task: Target ▼

Layout ▼ Visualization ▼

Visual Channel ▼ Data Type ▼

JSON Specification

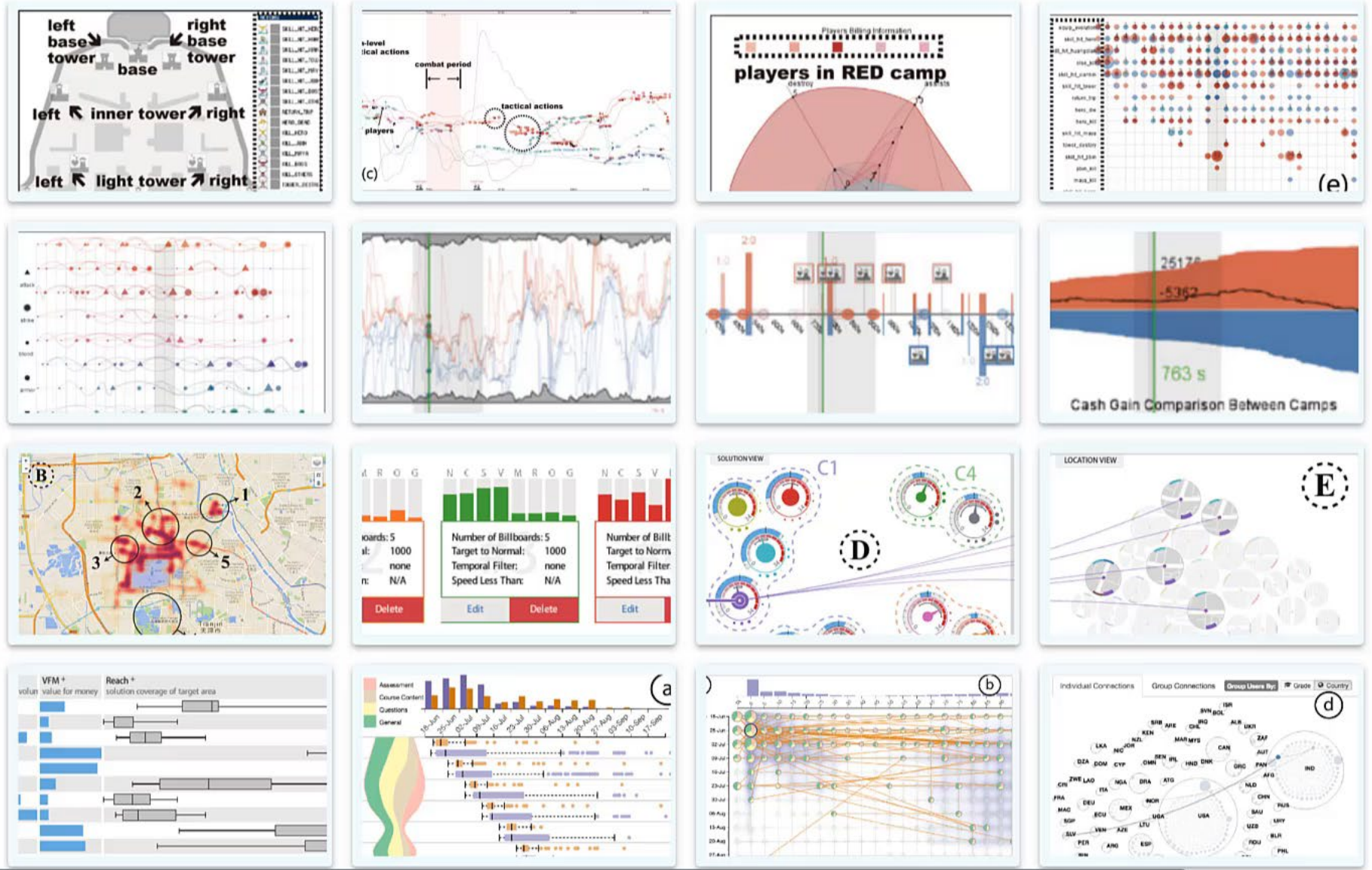
Use Specification

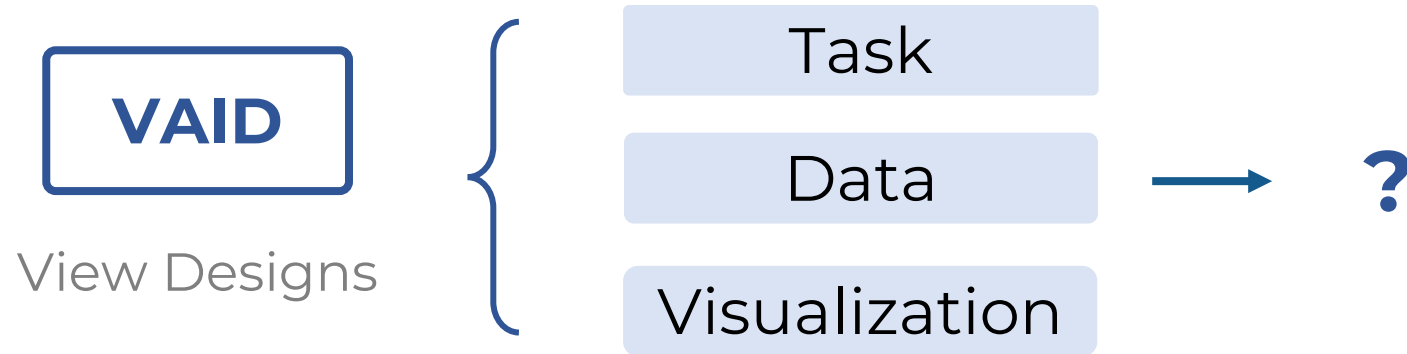
```

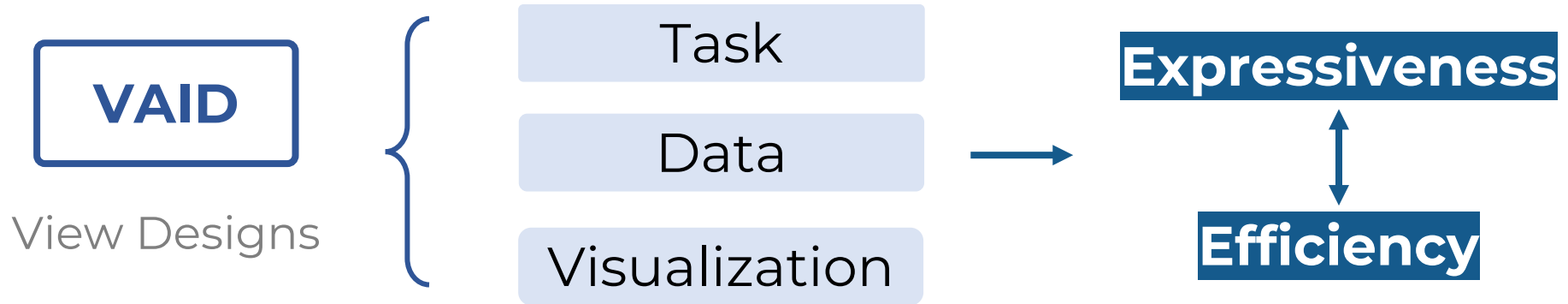
1 {
2   "x": {
3     "type": "+"
4   },
5   "y": {
6     "type": "+"
7   }
8 }

```

Retrieved Visualizations: 442 found







Workshop Study

Obtain the requirements for
understanding and indexing
VA view designs.



1

Motivation

2

Preliminary Study

3

VAID

4

User Study

5

Analysis

VAID-Alpha



Task

Data

Visualization



- Retrieve value
- Derive value
- Filter
- Find extremum
- Sort
- Determine range
- Characterize distribution
- Find anomalies
- Cluster
- Correlate
- Compare



VAID-Alpha



Task

Data

Visualization



- Quantitative (Q)
- Temporal (T)
- Ordinal (O)
- Nominal (N)
- Graph-related (G)



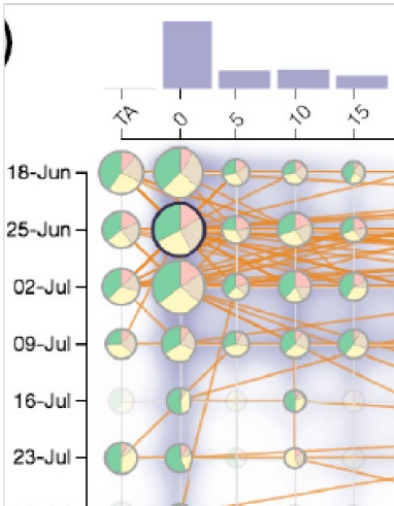
VAID-Alpha



Task

Data

Visualization



*Bar
(Pie,
Graph,
Heatmap)*



**VAID-
Alpha**


Vismages
VAST

**124 VA
systems**

442 Views

Task

Data

Type



Study Setup

VAID-Alpha



1

Motivation

2

Preliminary Study

3

VAID

4

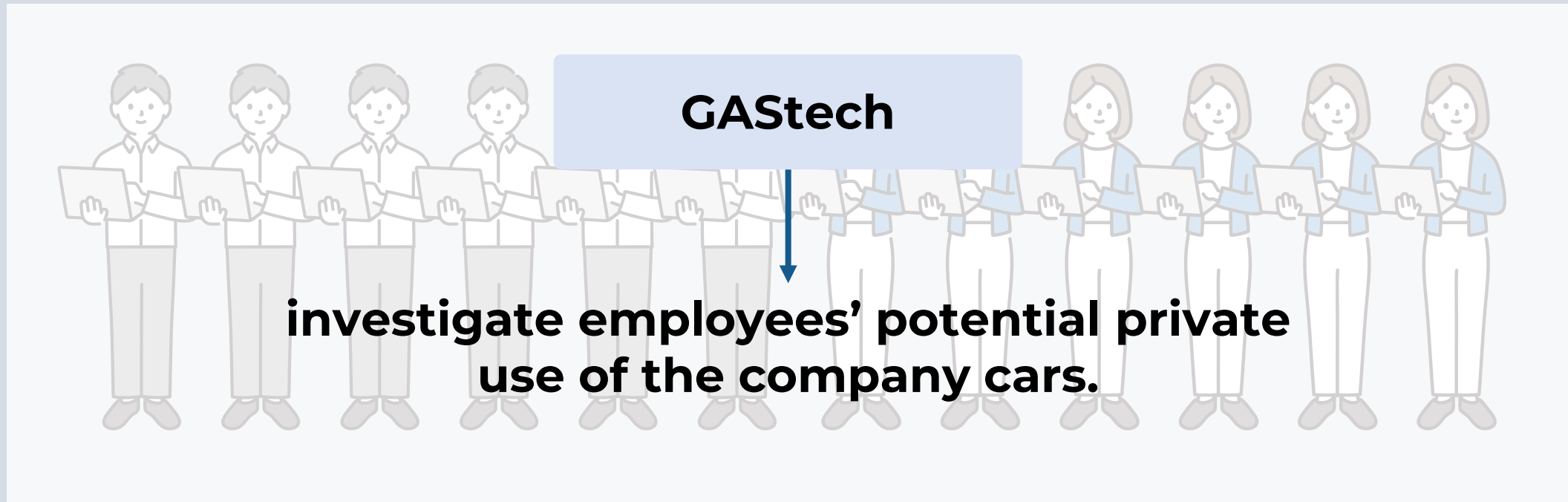
User Study

5

Conclusion

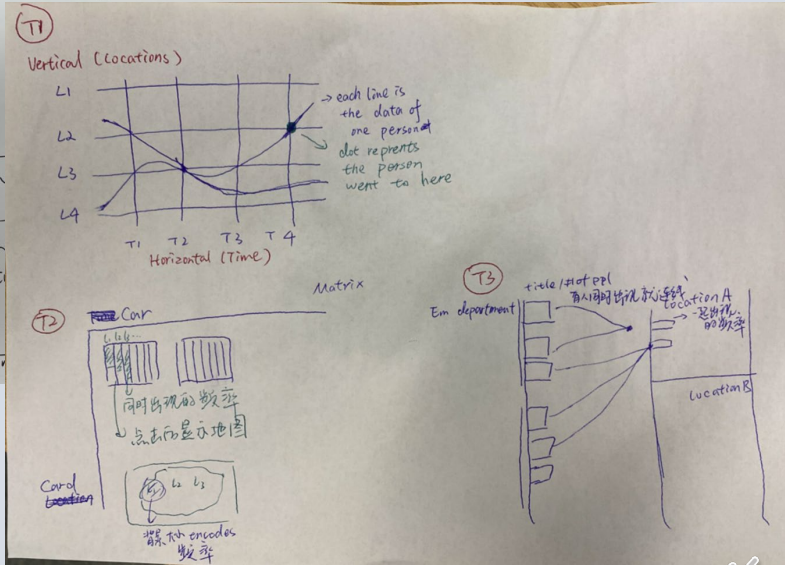
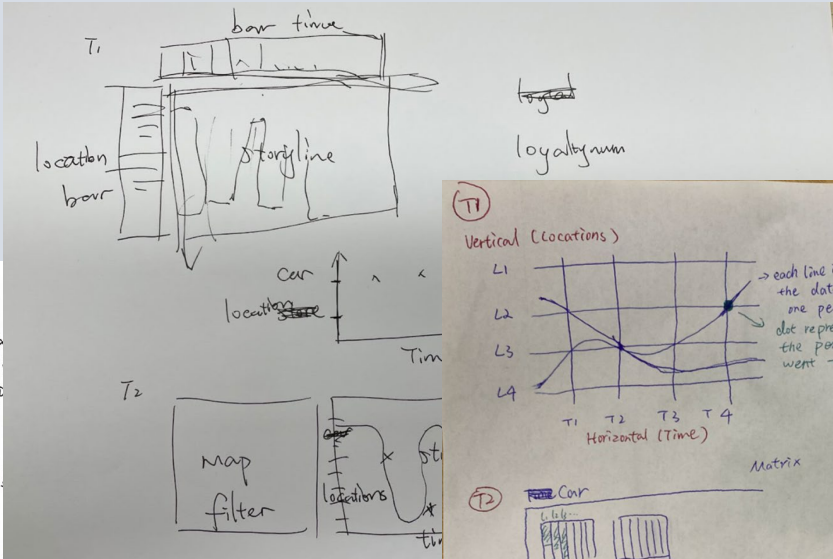
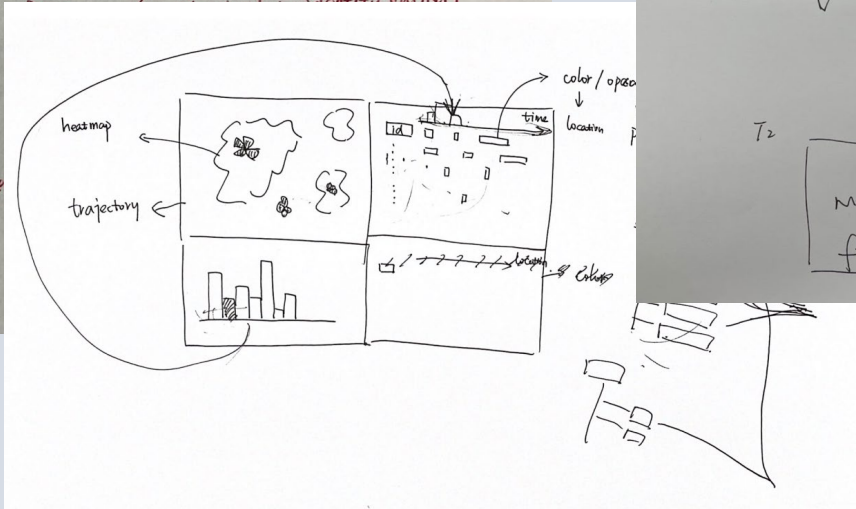
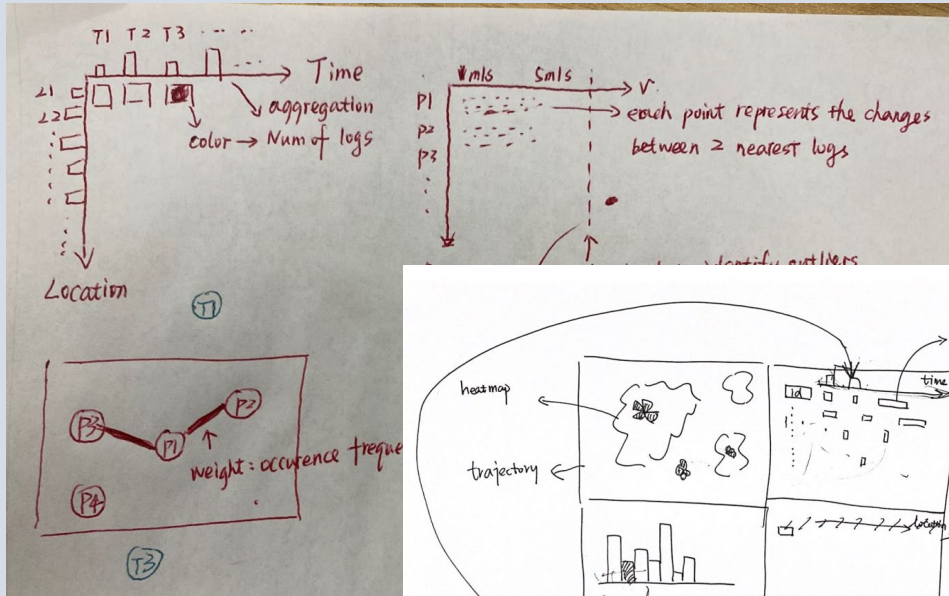
Study Setup

VAID-Alpha



Study Setup

VAID-Alpha



Requirements for the Index Design

Integration of **data** and **visualization**

Description of **visualization** composition

More detailed descriptions of analytical **tasks**

VAID = Task + Design



1

Motivation

2

Preliminary Study

3

VAID

4

User Study

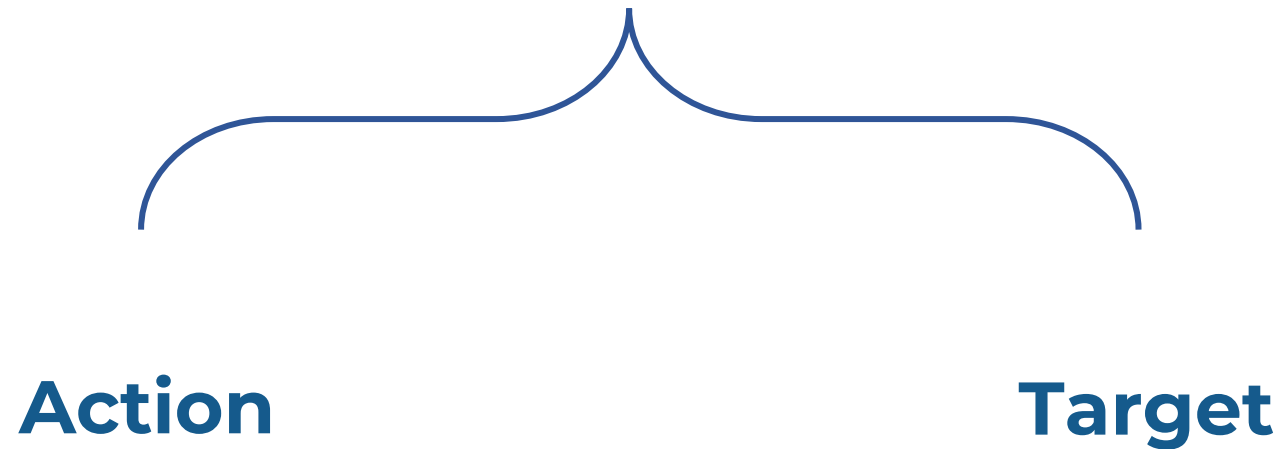
5

Conclusion

VAID = Task + Design

- Retrieve value
- Derive value
- Filter
- Find extremum
- Sort
- Determine range
- Characterize distribution
- Find anomalies
- Cluster
- Correlate
- Compare

VAID = **Task** + Design



1

Motivation

2

Preliminary Study

3

VAID

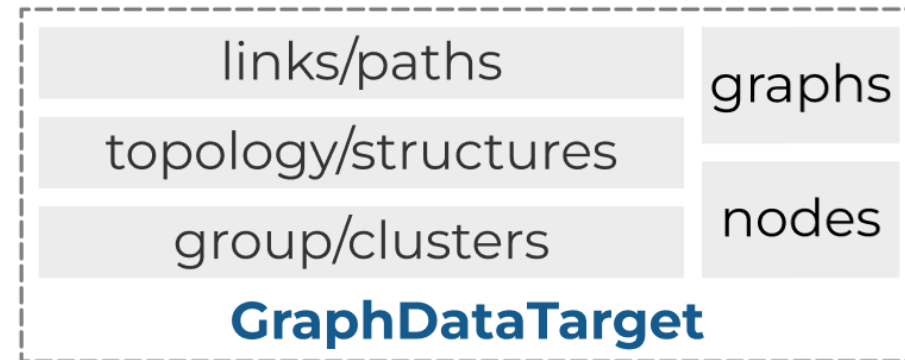
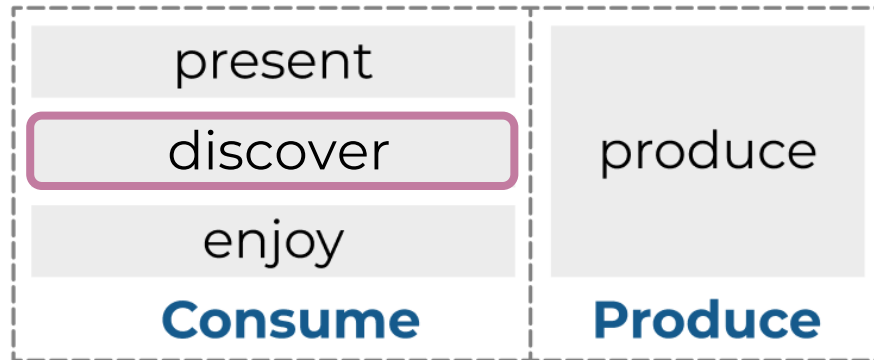
4

User Study

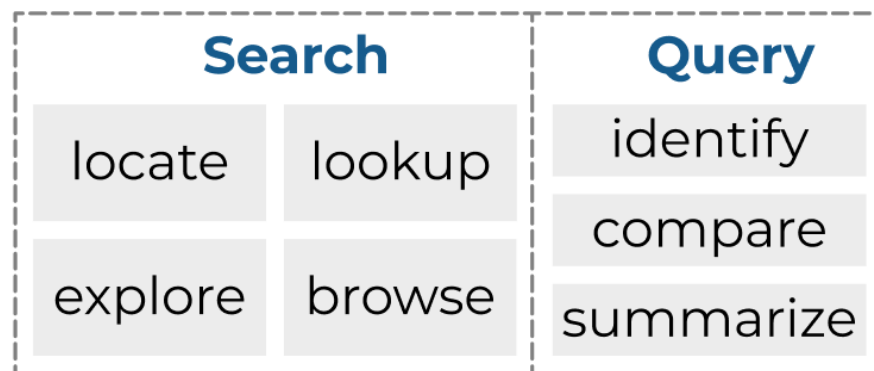
5

Conclusion

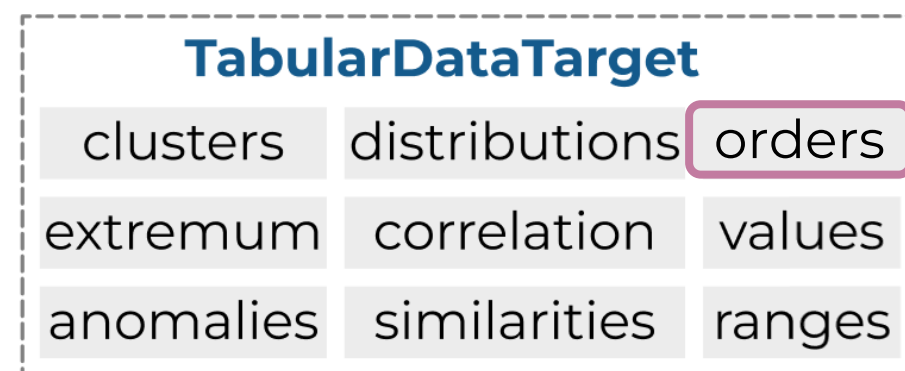
VAID = Task + Design



Action



Target



VAID = **Task** + Design

discover

orders

Action

Target

1

Motivation

2

Preliminary Study

3

VAID

4

User Study

5

Conclusion

VAID = **Task** + Design

(discover, order)

1

Motivation

2

Preliminary Study

3

VAID

4

User Study

5

Conclusion

VAID = Task + **Design**

Vega-Lite 



Mark, Encoding, Composition?...



VAID = Task + Design

Remark: Underscored fields are extended from Vega-Lite.

<i>bar</i>	<i>tick</i>	<i>boxplot</i>	<u><i>tree</i></u>
<i>line</i>	<i>rect</i>	<i>geoshape</i>	<u><i>surface</i></u>
<i>arc</i>	<i>point</i>	<u><i>Sankey</i></u>	<u><i>density</i></u>
<i>area</i>	<i>text</i>	<u><i>graph</i></u>	<u><i>Venn</i></u> ...

Mark, Encoding, Composition?...



VAID = Task + Design

Remark: Underscored fields are extended from Vega-Lite.

bar	tick	boxplot	<u>tree</u>
line	rect	geoshape	<u>surface</u>
arc	point	<u>Sankey</u>	<u>density</u>
area	text	<u>graph</u>	<u>Venn</u> ...

Mark, **Encoding**, Composition?...

[Channel] : Field, DataType, Aggregation?

text	radius	xOffset	quantitative		bin	count
theta	color	yOffset	nominal	temporal	min	mean
x	y	<u>node</u>	<u>link</u>	ordinal	<u>relational</u>	max ...



VAID = Task + Design

Remark: Underscored fields are extended from Vega-Lite.

<i>bar</i>	<i>tick</i>	<i>boxplot</i>	<u><i>tree</i></u>	<i>concat</i>
<i>line</i>	<i>rect</i>	<i>geoshape</i>	<u><i>surface</i></u>	<i>facet</i>
<i>arc</i>	<i>point</i>	<u><i>Sankey</i></u>	<u><i>density</i></u>	<i>layer</i>
<i>area</i>	<i>text</i>	<u><i>graph</i></u>	<u><i>Venn</i></u> ...	<u><i>nested</i></u>

Mark, Encoding, Composition?...

[Channel] : Field, DataType, Aggregation?

<i>text</i>	<i>radius</i>	<i>xOffset</i>	<i>quantitative</i>	<i>bin</i>	<i>count</i>		
<i>theta</i>	<i>color</i>	<i>yOffset</i>	<i>nominal</i>	<i>temporal</i>	<i>min</i>	<i>mean</i>	
<i>x</i>	<i>y</i>	<u><i>node</i></u>	<u><i>link</i></u> ...	<i>ordinal</i>	<u><i>relational</i></u>	<i>max</i>	...



VAID = Task + Design

Remark: Underscored fields are extended from Vega-Lite.

<i>bar</i>	<i>tick</i>	<i>boxplot</i>	<u><i>tree</i></u>	<i>concat</i>
<i>line</i>	<i>rect</i>	<i>geoshape</i>	<u><i>surface</i></u>	<i>facet</i>
<i>arc</i>	<i>point</i>	<u><i>Sankey</i></u>	<u><i>density</i></u>	<i>layer</i>
<i>area</i>	<i>text</i>	<u><i>graph</i></u>	<u><i>Venn</i></u> ...	<u><i>nested</i></u>

Mark, Encoding, Composition?...


[Channel] : Field, DataType, Aggregation?

<i>text</i>	<i>radius</i>	<i>xOffset</i>	<i>quantitative</i>	<i>bin</i>	<i>count</i>		
<i>theta</i>	<i>color</i>	<i>yOffset</i>	<i>nominal</i>	<i>temporal</i>	<i>min</i>	<i>mean</i>	
<i>x</i>	<i>y</i>	<u><i>node</i></u>	<u><i>link</i></u> ...	<i>ordinal</i>	<u><i>relational</i></u>	<i>max</i>	...




VAID = Task + Design

Mark, Encoding, Composition?...




Graph-Related

```
{
  mark: 'graph',
  node: {
    field: {...},
    type: 'node'
  },
  link: {
    field: {...},
    type: 'relational'
  },
  width: {...},
}
```




Concat

```
{
  concat: {
    layout:
    'horizontal/
    vertical/
    crossing',
  },
  spec: [
    {vis_1},
    {vis_2}...
  ]
}
```




Layer

```
{
  layer: [
    {vis_1},
    {vis_2},
    ...
  ]
}
```




Facet

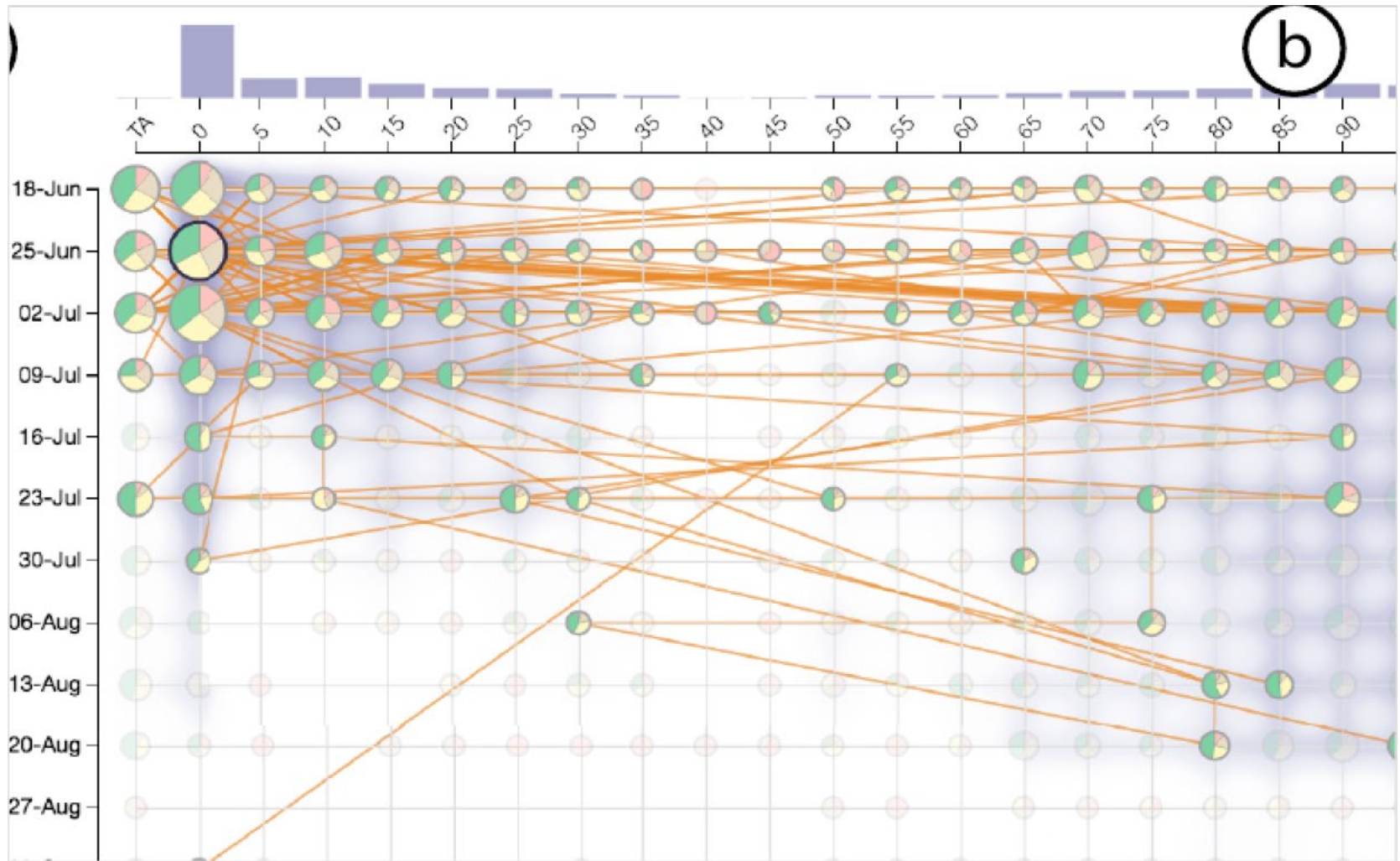
```
{
  facet: {
    row: {},
    column: {},
  },
  spec: {
    mark: '...',
    encoding: {}
  }
}
```



Nested

```
{
  nested: {
    parent: {
      canvas: 'node',
      mark: '...',
      encoding: {}
    },
    children: {
      mark: '...',
      encoding: {}
    }
  }
}
```





```

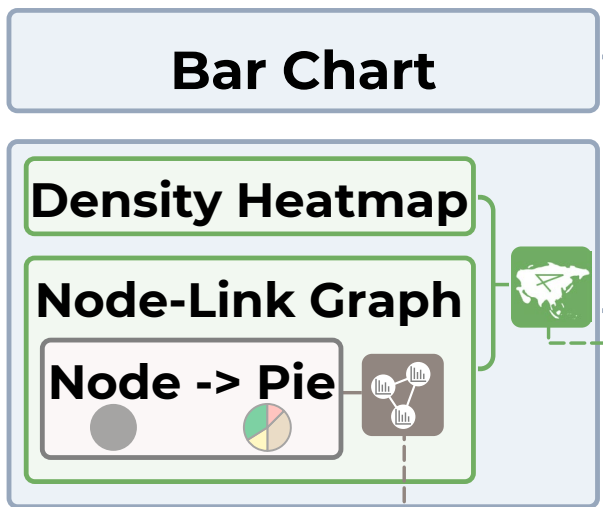
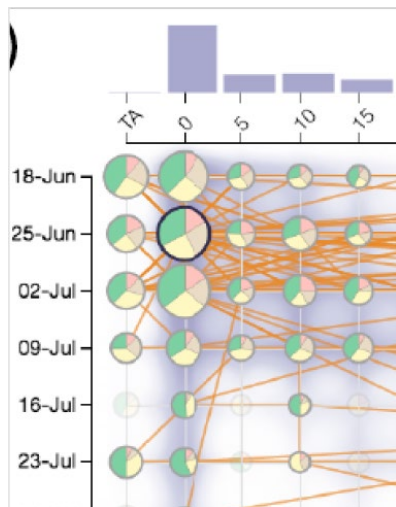
mark: 'bar',
encoding: {
  x: { field: 'user_group', type: 'nominal' },
  y: { field: 'post', type: 'nominal',
      aggregate: 'count' },
}

```

```

{
  concat: { layout: 'vertical' },
  spec: [
    { bar part },
    { layer: [
      { density part },
      { nested: {
        parent: { point part },
        child: { arc part }
      } },
    { graph part }
  ]
}

```



**VAID-
Alpha**

iMages
Vismages
VAST

**124 VA
systems**

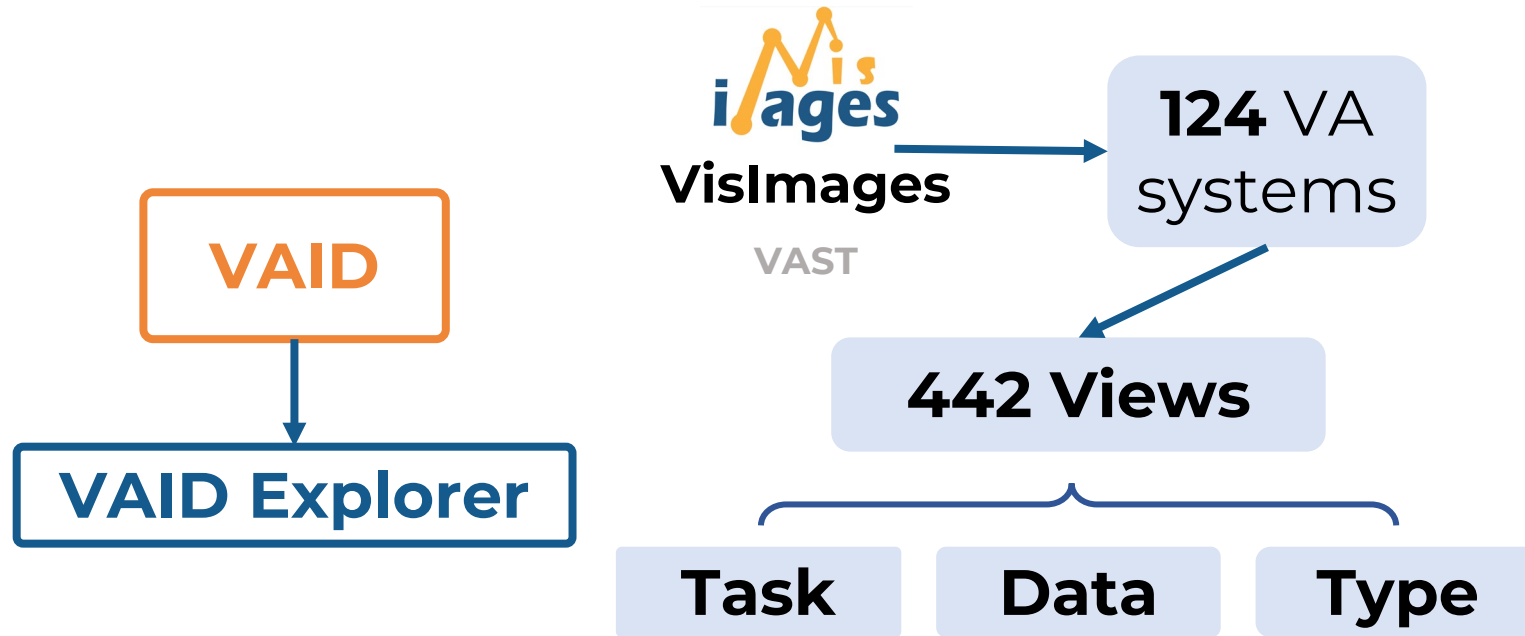
442 Views

Task

Data

Type





VAID Explorer

Query Panel

Filtering View

Task: Action Task: Target

Layout Visualization

Visual Channel Data Type

 nominal, temporal

JSON Specification

Use Specification

```

1 {
2   "x": {
3     "type": "*"
4   },
5   "y": {
6     "type": "*"
7   }
8 }

```

Indexing View

SEARCH

RESET ↻

The visualization grid contains the following types of charts:

- Top-left:** A network graph with nodes labeled 'left base tower', 'right base tower', 'left inner tower', and 'right light tower'.
- Top-middle:** A network graph with nodes labeled 'oval', 'combat period', and 'tactical actions'.
- Top-right:** A heatmap visualization labeled '(e)'.
- Middle-left:** A bar chart with a legend for 'Newborn', 'Counter Cluster', 'Clusters', and 'Genes'.
- Middle-middle:** A complex dashboard with multiple sub-charts labeled A, C, E, and F.
- Middle-right:** A bar chart with four vertical bars.
- Bottom-left:** A sunburst chart labeled 'G' showing hierarchical data.
- Bottom-middle:** A scatter plot with a line graph overlaid, labeled 'scatter plot'.
- Bottom-right:** A network graph labeled '(a)'.
- Bottom-left (small):** A table with columns for 'id', 'name', 'description', 'start', 'end', 'status', and 'priority'.
- Bottom-middle (small):** A heatmap with a color scale from red to black.
- Bottom-right (small):** A bar chart with a date axis from Feb 02 to Mar 02, labeled 'A.2'.



VAID Explorer

Query Panel **Filtering View**

Filters

Task: Action Task: Target

Layout Visualization

Visual Channel Data Type
nominal, temporal

JSON Specification

Use Specification

```
1 {  
2   "x": {  
3     "type": ""  
4   },  
5   "y": {  
6     "type": ""  
7   }  
8 }
```

Indexing View

SEARCH

RESET ↻

Gallery View

mark: 'bar',
encoding: {
 x: { field: 'user_group', type: 'nominal' },
 y: { field: 'post', type: 'nominal',
 aggregate: 'count' },
}



VAID Explorer

Query Panel **Filtering View** Gallery View

Filters

Task: Action Task: Target

Layout Visualization

Visual Channel Data Type
nominal, temporal

JSON Specification

Use Specification

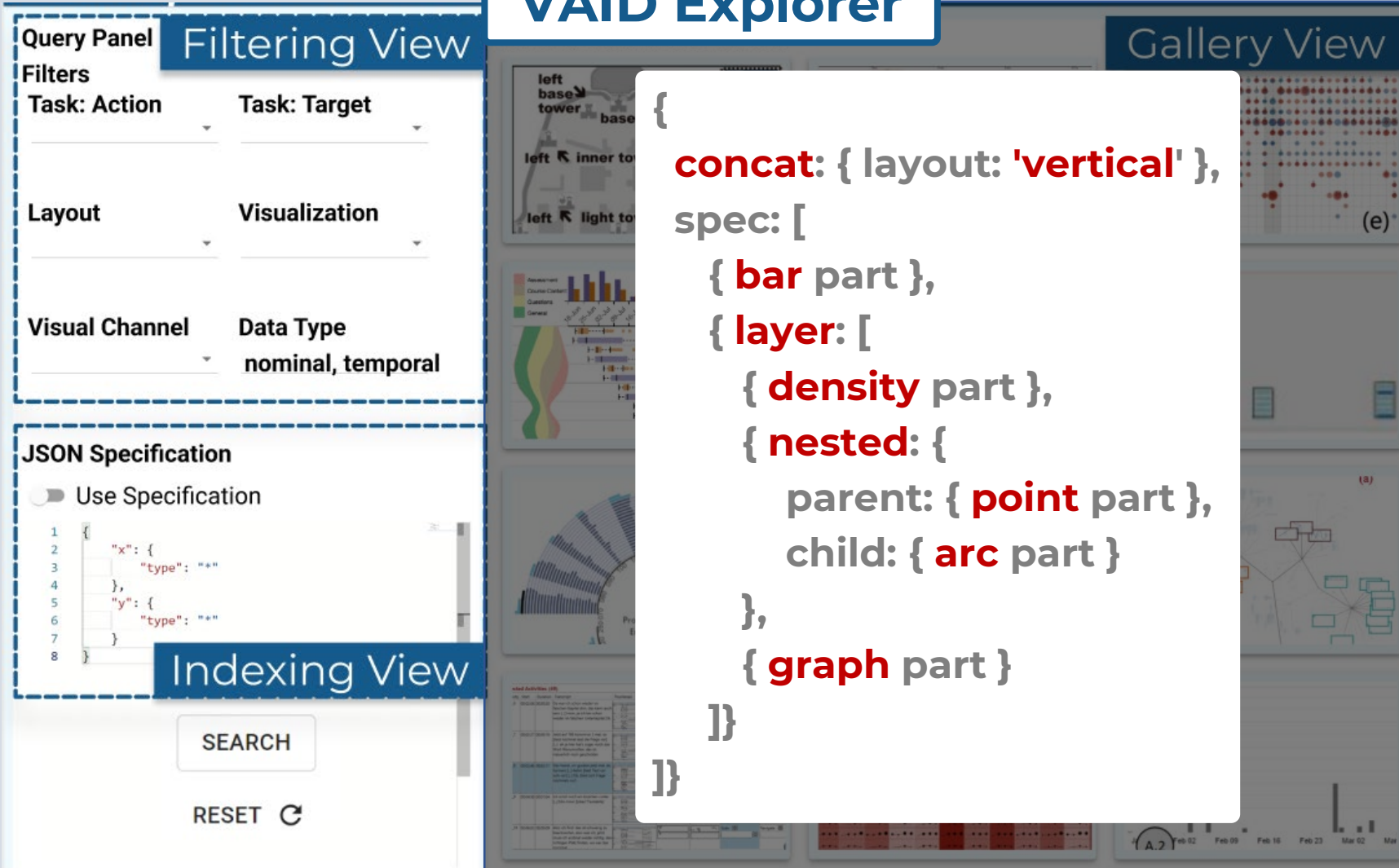
```
1 {  
2   "x": {  
3     "type": ""  
4   },  
5   "y": {  
6     "type": ""  
7   }  
8 }
```

Indexing View

SEARCH

RESET ↻

```
{  
  concat: { layout: 'vertical' },  
  spec: [  
    { bar part },  
    { layer: [  
      { density part },  
      { nested: {  
        parent: { point part },  
        child: { arc part }  
      } },  
    { graph part }  
  ]  
}
```



VAID Explorer

The interface is divided into several panels:

- Query Panel:** Includes filters for 'Task: Action' and 'Task: Target'.
- Filtering View:** Shows a diagram of a tower base with 'left base tower' and 'right base tower' labels.
- Gallery View:** Displays a grid of small thumbnail visualizations.
- Detail View:** Shows a large visualization (e) titled 'high-level tactical actions'. It features a grid of colored dots (red, blue, orange) representing data points. The y-axis lists various skills and actions like 'equip_evolution', 'skill_ht_hero', 'skill_ht_huangshan', etc. The x-axis represents time from 00 to 1800. Below the grid is a 'Specification' panel with JSON code defining the visualization's structure, including nested fields for 'time', 'action_type', and 'action'. To the right of the visualization is a metadata sidebar with fields like 'Title', 'Action-Target Pairs', 'Compositions', 'Mark Types', 'Data Types', 'Channels', 'Aggregates', and 'Caption'.



User Study

VAID **can** assist users in view design?

VAID Explorer



1

Motivation

2

Preliminary Study

3

VAID

4

User Study

5

Conclusion

Study Setup

VAID



1

Motivation

2

Preliminary Study

3

VAID

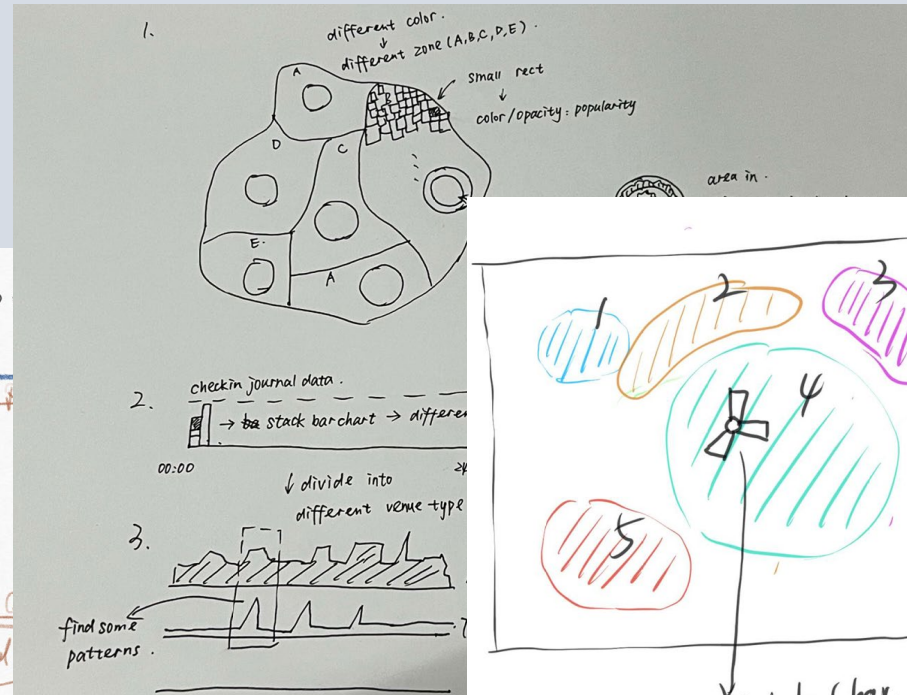
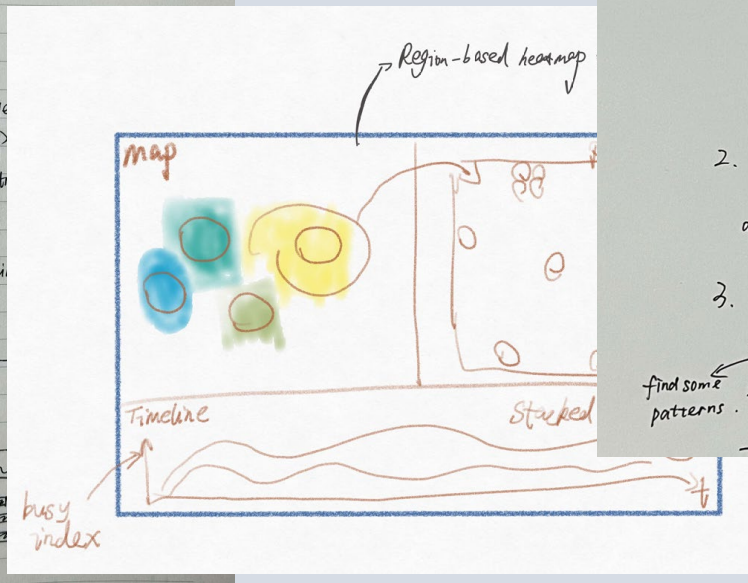
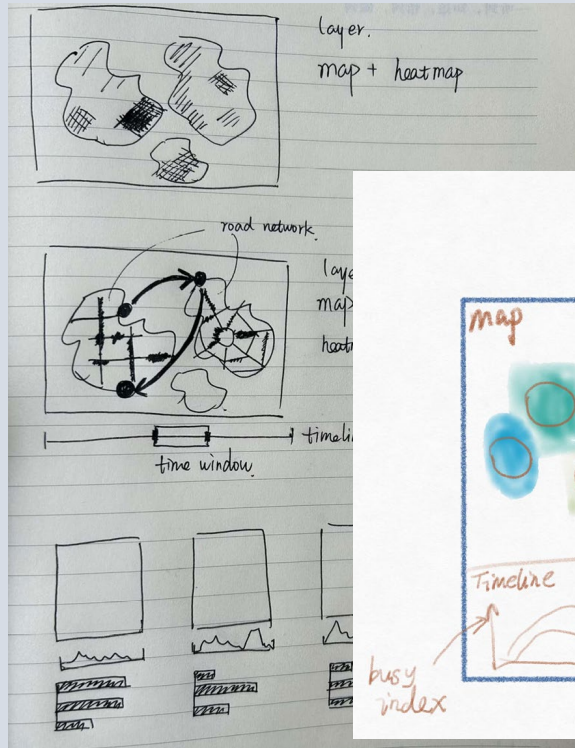
4

User Study

5

Conclusion

Results



Results and Feedback

- VAID is **easy to understand** and **benefits design understanding**.

Understandability: 4.75 ± 0.35

VAID is easy to understand.



Interpretability: 4.41 ± 0.29

VAID helps interpret the retrieved designs.



strongly disagree = 1

disagree = 2

neutral = 3

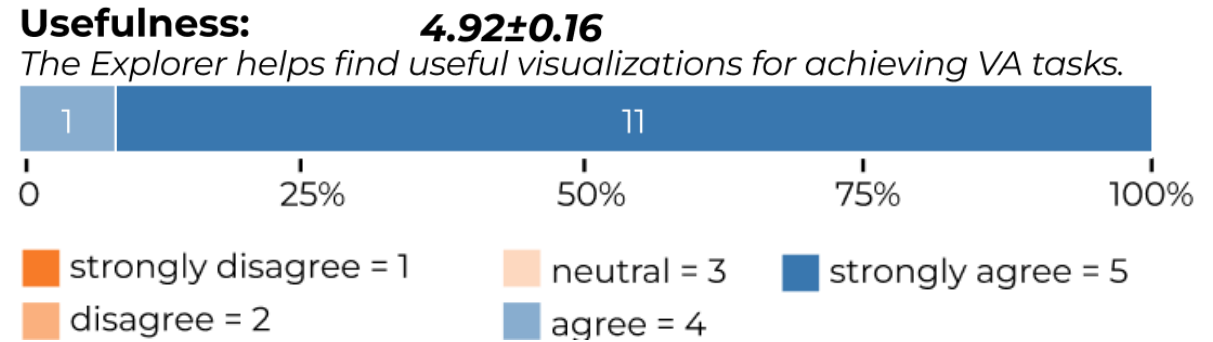
agree = 4

strongly agree = 5



Results and Feedback

- VAID Explorer enables users to **swiftly derive initial designs** based on the given question.



U12:

“Previously, I required **time** to grasp background information; however, now I can randomly select filter parameters to explore potential designs...”

U11:

“The filter options **align with my way of thinking** about the design question. I find it easy to kickstart the process, given that the question description provides the necessary information...”



Results and Feedback

- VAID facilitates **comprehensive search.**

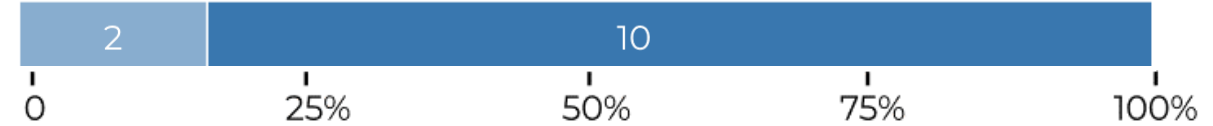
Satisfaction: **4.08±0.44**

The searching results based on VAID are satisfactory.



Diversity: **4.83±0.22**

The Explorer provides diverse design examples for visual analytics.



strongly disagree = 1

neutral = 3

strongly agree = 5

disagree = 2

agree = 4

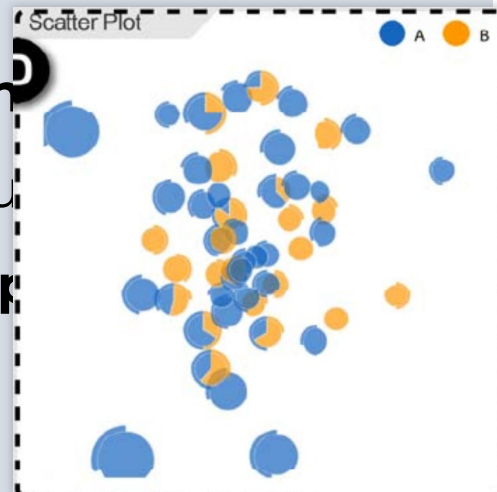
U5:

“VAID enables designing VA systems in a manner of **progressive exploration**, identification, and localization of anomalies.”



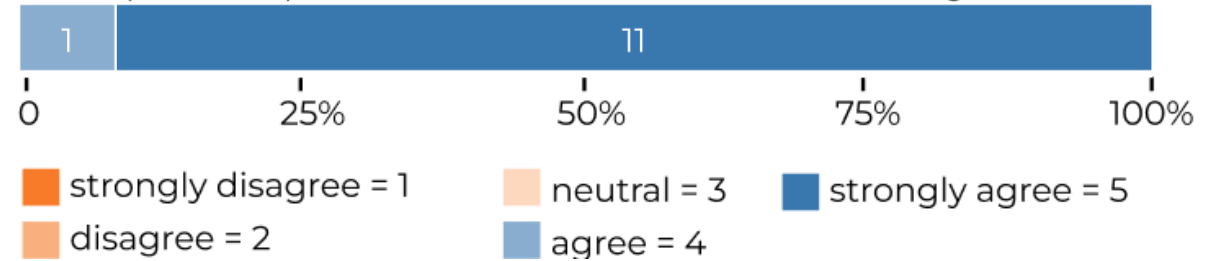
Results and Feedback

- VAID facilitates **in design**, helping users refine their designs **step**



Usefulness: **4.92±0.16**

The Explorer helps find useful visualizations for achieving VA tasks.



U10:

"I usually use several basic charts to meet design requirements. After that, I explore ways to refine the design by integrating these charts into a unified view."



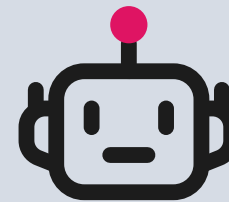
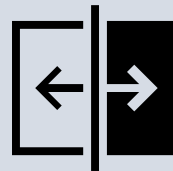
Results and Feedback

- VAID enhances design **aesthetics**.



Opportunities for Future Research

- VAID offers the potential to enhance view design **assessment**.
- VAID presents the opportunity to simplify **comparisons** of view designs.
- we envision VAID as an initial step toward enhancing the VA **automation**.



VAID: Indexing View Designs in Visual Analytics System

- **Requirements** for indexing and understanding views
- An effective index structure **VAID** for VA designs
- A **user study** to demonstrate the usefulness of VAID

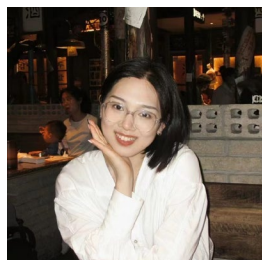
VAID: Indexing View Designs in Visual Analytics System

The screenshot displays the VAID system interface. On the left is a 'Query Panel' with filters for 'Task: Action' (set to 'Action'), 'Task: Target' (set to 'Target'), 'Layout', 'Visualization', 'Visual Channel', and 'Data Type'. Below the filters is a 'JSON Specification' section with a 'Use Specification' toggle and a JSON code editor containing the following code:

```
1 {  
2   "x": {  
3     "type": "+"  
4   },  
5   "y": {  
6     "type": "+"  
7   },  
8 }
```

The main area shows 'Retrieved Visualizations: 442 found' and a grid of various visualizations including maps, charts, and network diagrams. Some visualizations are labeled with letters like 'A', 'B', 'C', 'D', and 'E'.

<https://yiyinyinguu.github.io>



Lu
Ying



<https://VIS-VAID.github.io>