

Guest & Research Lectures

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CPSC 547, Information Visualization
7 December 2022
<http://www.cs.ubc.ca/~tmm/courses/547-22>

Today

- Steve Kasica, UBC
 - qual study: TableScraps, 15 min
 - Q&A, 5 min
- Stephen Kobourov, Univ. Arizona
 - algorithms: Scalable Graph Drawing w/ SGD, 15 min
 - algorithms: MetroSets, 15 min
 - Q&A 5-10 min
- Mara Solen, UBC
 - survey: VisLit, 15 min
 - Q&A, 5 min
- break, 10 min
- me
 - design spaces: Timelines Revisited, GEViT, 30 min
 - design studies: Ocupado, Aggregated Dendrograms, 25 min
 - imperfect models: TimelineCurator, 15 min
 - Q&A, 10 min

Steve Kasica

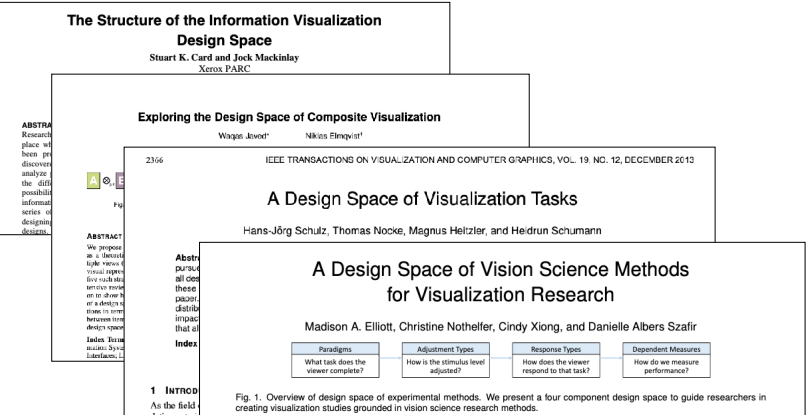
Stephen Kobourov

Mara Solen

break

design spaces

Design spaces: Continuing theme



Design spaces: What are they?

- impose **systematic structure** on set of possibilities for specific problem
 - to capture the key variables at play
 - to support **reasoning about design choices**
- delineate
 - **cross-cutting** / independent / orthogonal
 - **axes** / dimensions / categories
- many names
 - design spaces, taxonomies, typologies, classifications, frameworks, models, ...
 - space within which to express design patterns [Javed/Elmqvist]

Design spaces: What are they for?

- describe and analyze portions of design space to **understand differences** among designs & **suggest new** possibilities [Card & Mackinlay 1997]
- design spaces provide an **actionable** structure for systematically reasoning about solutions [Elliott et al 2020]
- taxonomies increase **cognitive efficiency** & support **inferences** [Ralph. Toward Methodological Guidelines for Process Theories & Taxonomies in Software Engineering. IEEE TSE 2020]
 - by grouping similar instances together to facilitate **reasoning about classes** rather than instances

Design spaces: How to assess?

- Michel Beaudoin-Lafon, *Designing Interaction, not Interfaces*. AVI 2004.
 - **descriptive** power: ability to describe significant range of existing examples
 - **evaluative** power: ability to help assess multiple design alternatives
 - **generative** power: ability to help designers create new designs

Design spaces: How to create?

- **open coding** source material
 - grounded theory / thematic analysis / qualitative analysis
- **literature** review
 - synthesize across existing theories, compare & contextualize
- personal **reflection**
 - reflective synthesis
- complex combinations...

Design spaces: Multiple examples

- datatype: temporal, **timeline** visual encoding
- domain: **genomic epidemiology**, paper figure visual encoding
- domain: **journalism**, data **wrangling** activities
- domain agnostic: **abstract tasks**

Timelines

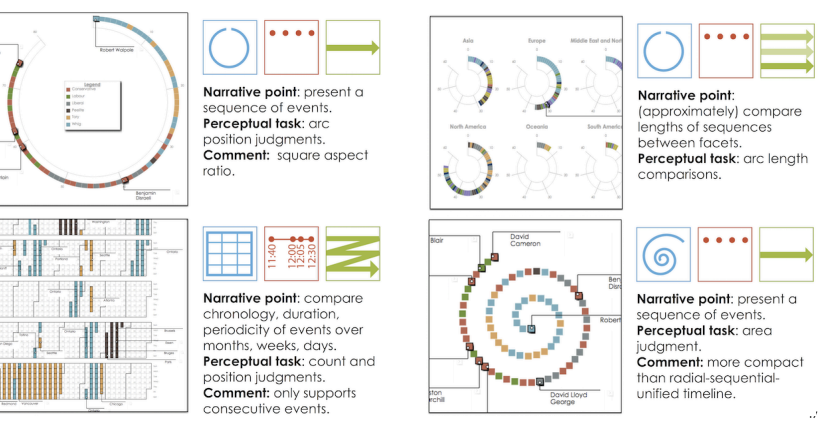
Timelines Revisited
A Design Space and Considerations for Expressive Storytelling
<https://timelinesrevisited.github.io/>
<https://timelinestoryteller.com>

Timelines Revisited: A Design Space and Considerations for Expressive Storytelling
Brehmer, Lee, Bach, Henry Riche, Munzner. IEEE TVCG 23(9):2151-2164

Design space with three axes

- representation
- scale
- layout

Combinations: Characterize narrative, perceptual



Viable combinations



Process

- **create** design space
 - **assemble** source material corpus: 145 timeline visualizations & timeline tools
 - **open code** group timelines together, select example for group, sketch alternatives
 - result: 3-axis design space
- **analyze** design space
 - 24 unique combinations (of 100) found in corpus
 - 20 we deemed viable

Assessment & adoption

- descriptive power
 - **validated** coverage through checking 118 additional timelines ("test set")
 - all timelines can be described (263 total)
 - 253 characterized as viable
- generative power
 - **implemented** sandbox authoring software for 20 viable designs
 - & transitions between them
 - **created** designs for 28 representative datasets
 - 7 full story videos
- adoption
 - **open sourced** & distributed as Microsoft **product**
 - free browser version at <https://timelinstoryteller.com/>
 - free add-on for PowerBI

Genomic Epidemiology

A systematic method for surveying data visualizations and a resulting genomic epidemiology visualization typology:

GEViT

<https://amcrisan.github.io/gevit>

A systematic method for surveying data visualizations and a resulting genomic epidemiology visualization typology: GEViT. Crisan, Gardy, Munzner. Oxford Bioinformatics 35(10):1668-1676, 2018.

Anamaria Crisan
@amcrisan



Jenn Gardy
@jennifergardy



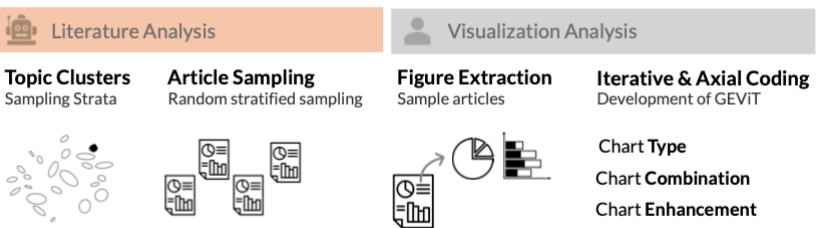
Propose typology creation method: mixed qual and quant

- Analyzed research articles
- Some analyses are automated (🤖) and others are manual (👤)

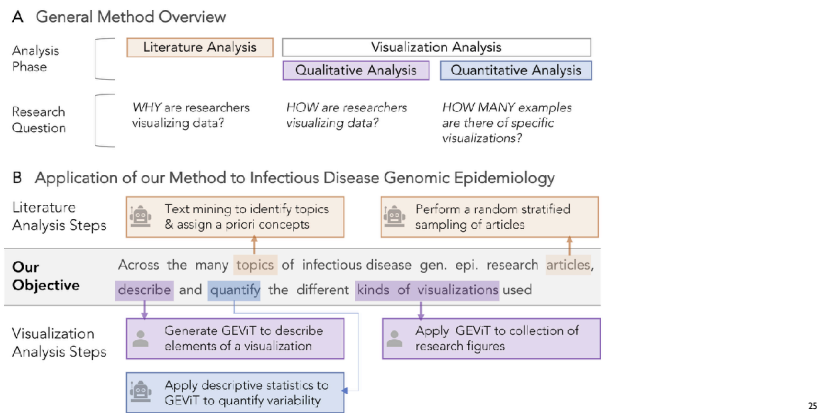


Use method to develop typology in specific domain

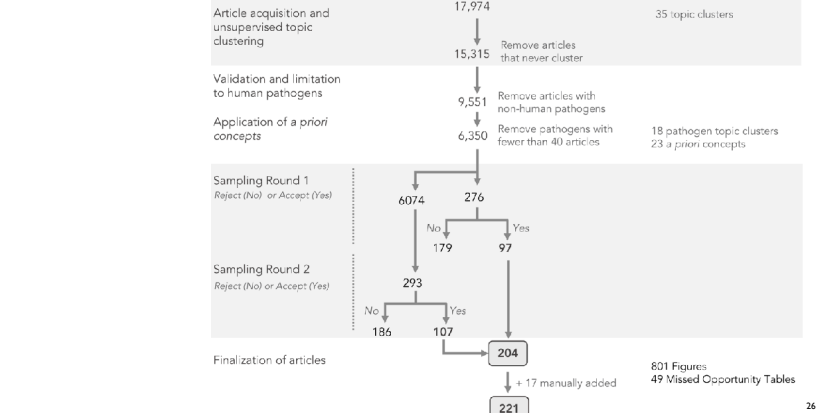
- Developed a Genomic Epidemiology Visualization Typology (GEViT)



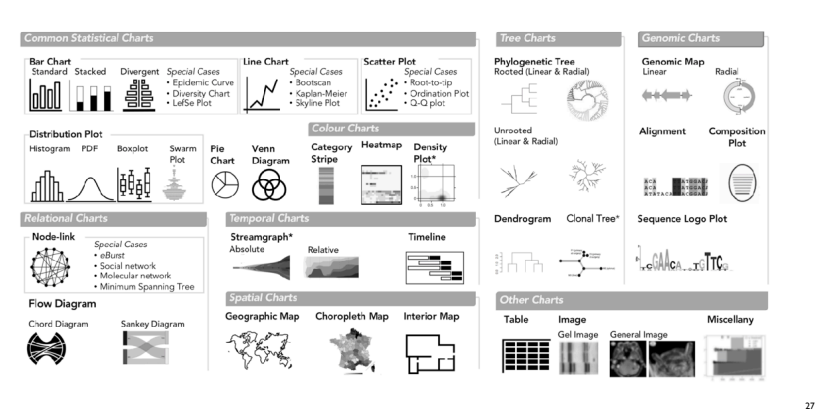
Domain prevalence design space



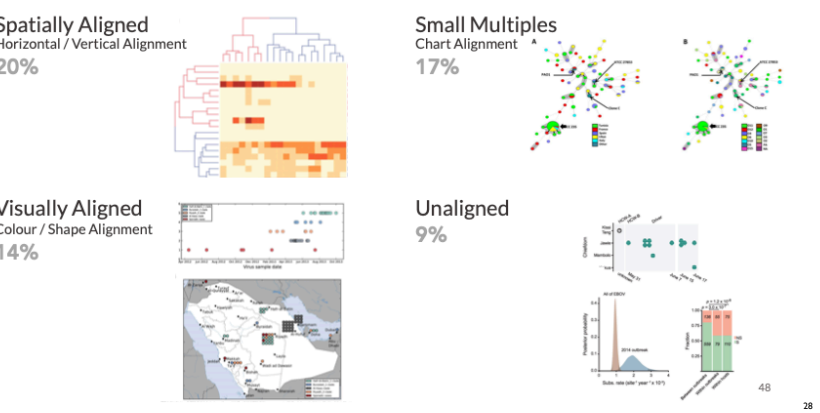
By the numbers



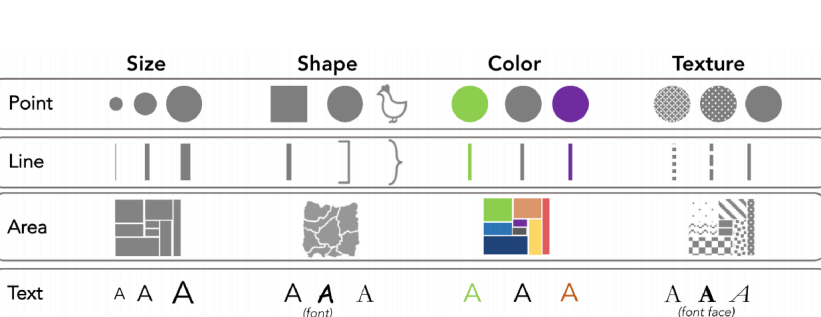
Design space axis: Chart types used in genEpi



Design space axis: Chart combinations of heterogeneous data

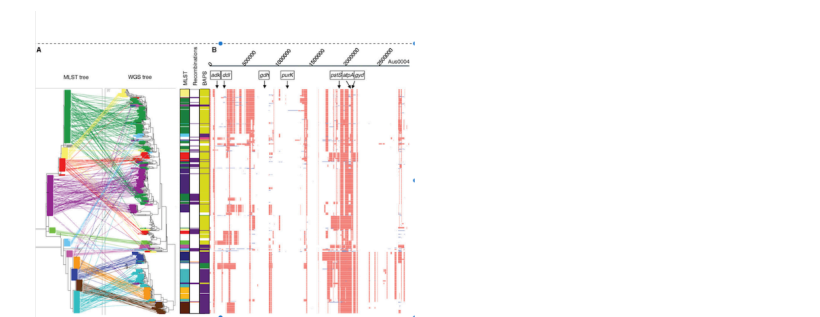


Design space axis: Enhancement choices, atop base chart types

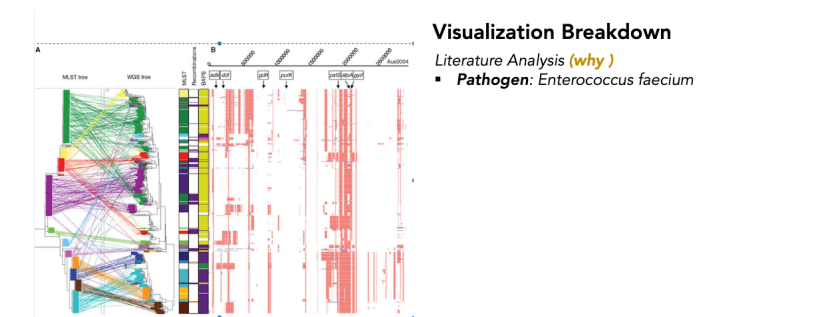


Current Practice >80% of all figures have some enhancement

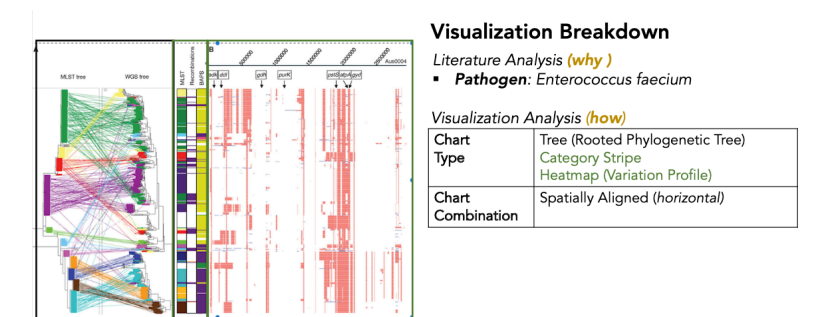
GEViT example



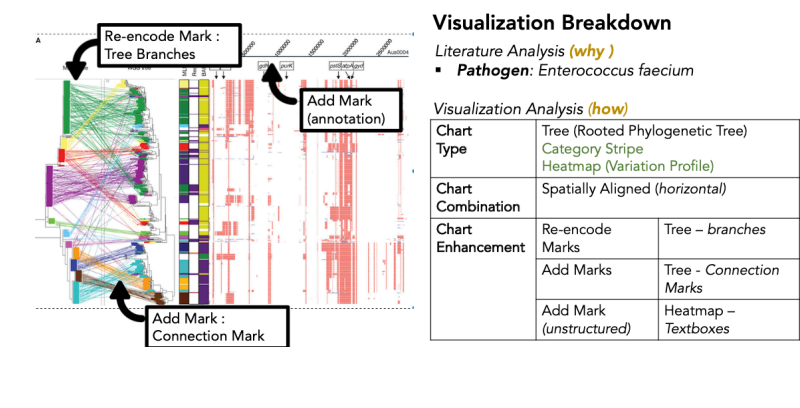
GEViT example



GEViT example



GEViT example



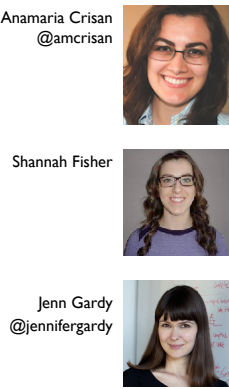
Assessment

- descriptive power
 - provided common language for describing data visualization in genEpi
 - established gap: **unmet tooling needs**
 - no existing tool handled full complexity of what people do manually
- evaluative power
 - **revealed shortfalls** in practices of some genEpi stakeholders
 - eg overuse of text
- generative power
 - validated in followup GEViTRec work
 - **build** automatic recommender system using domain prevalence design space

GEViTRec:
Data Reconnaissance Through Recommendation Using a Domain-Specific Visualization Prevalence Design Space

<https://github.com/amcrisan/GEViTRec>

GEViTRec: Data Reconnaissance Through Recommendation Using a Domain-Specific Visualization Prevalence Design Space. Crisan, Fisher, Gardy, Munzner. IEEE TVCG 29(12):4855-4872, 2022.



Summary: Multiple design spaces

| Design Space | Open Coding Source Material | Sampling Strategy | Reflective Synthesis Timing | Vis Research Literature |
|--------------------------|-----------------------------|--|-----------------------------|-------------------------|
| timeline visual encoding | standalone timelines | assembled corpus | early | some source material |
| genEpi visual encoding | figures from papers | stratified random sampling with topic clusters | - | - |
| wrangling activities | software from repos | diversity criteria | late | terms: light mapping |

Summary: Multiple design spaces

| Design Space | Descriptive Power | Generative Power | Descriptive vs Generative | Evaluative Power |
|--------------------------|--|--|--|------------------|
| timeline visual encoding | validated against test set | software implementation of authoring system, used to create example gallery/videos | analysis to characterize viable subset | |
| genEpi visual encoding | systematic method yields comprehensive coverage | software implementation of automatic recommender (followup) | same (detailed) | |
| wrangling activities | high precision, gaps / divergence found for domain | concise framework (followup implementation TBD) | develop entirely new framework | |

Design spaces: How to assess? Larger context: theory types

- Ben Shneiderman, *Designing the User Interface*: descriptive, explanatory, prescriptive, predictive
- Paul Ralph, *Toward Methodological Guidelines for Process Theories & Taxonomies in Software Engineering*, IEEE TSE 2020
 - theory types
 - theories for **understanding**: organizing what is happening into useful categories (taxonomies)
 - **process** theories: how something happens (often taxonomies++)
 - **variance** theories: why something happens, causal relationships between constructs
 - predictive
 - relevant criteria for taxonomies
 - **yes**: parsimony, transferability, theoretical saturation
 - **sometimes**: utility, originality, resonance/believability, testability
 - **no**: statistical generalizability, construct validity, internal validity, conclusion validity


design studies

Two design studies


- facilities management
- biology



Biology by Isacar Iantaru from the Noun Project Business by Colourcreedesign from the Noun Project



Michael Oppermann



Ocupado

Visualizing Location-Based Counts Over Time Across Buildings

<http://www.cs.ubc.ca/labs/imager/tr/2020/ocupado/>

Ocupado: Visualizing Location-Based Counts Over Time Across Buildings. Oppermann and Munzner. Computer Graphics Forum (Proc. EuroVis 2020) 39(3):127-138 2020.

Location-Based Counts



Previous measurement required physical counting or installation of additional hardware.



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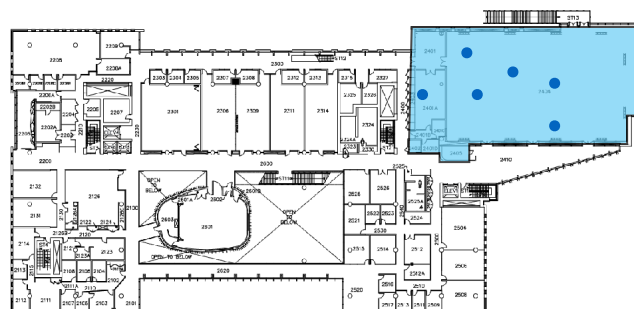


Previous visualization attempts were limited in space and time.

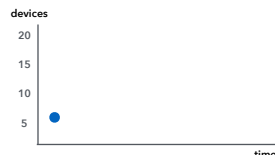
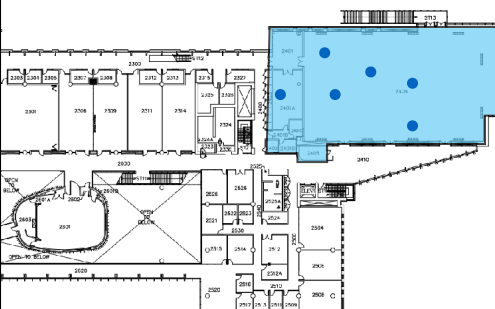


Design Study

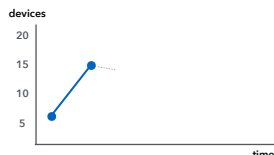
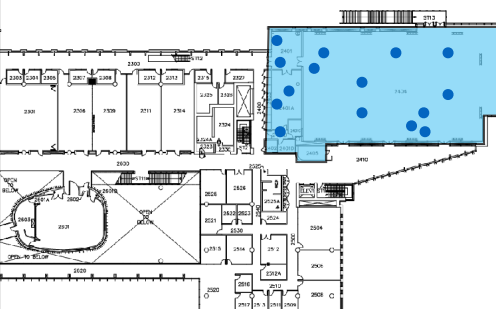
WiFi Connections: Location-Based Counts

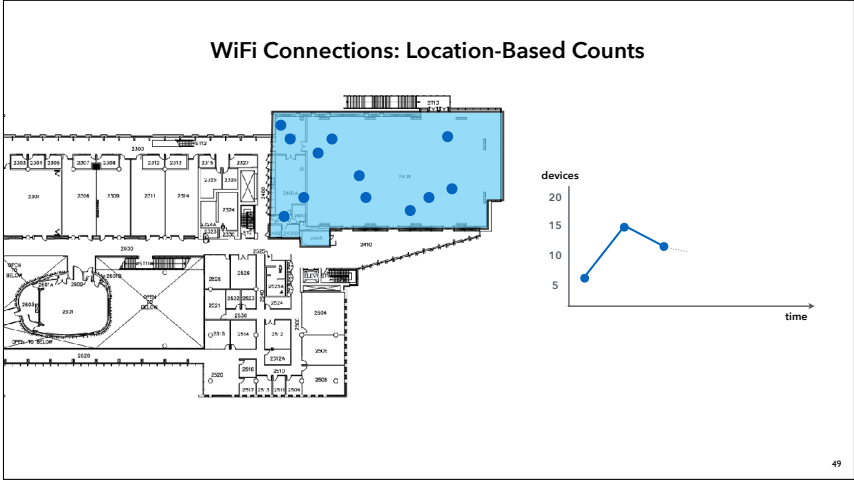
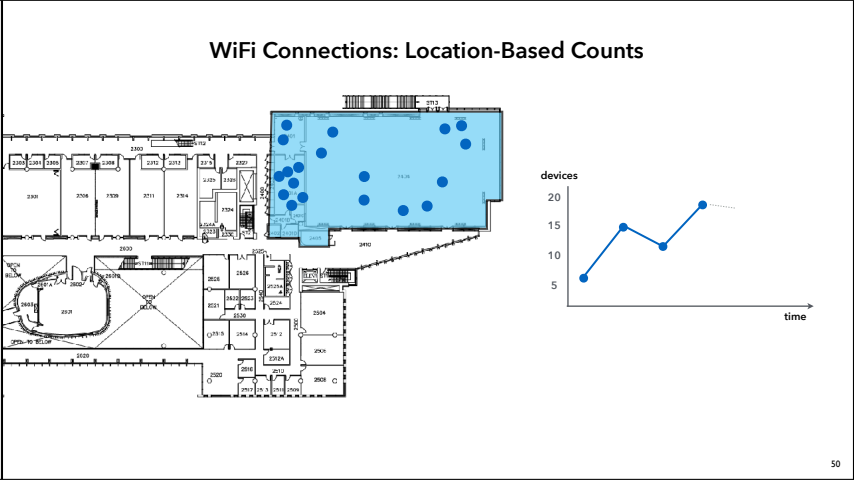
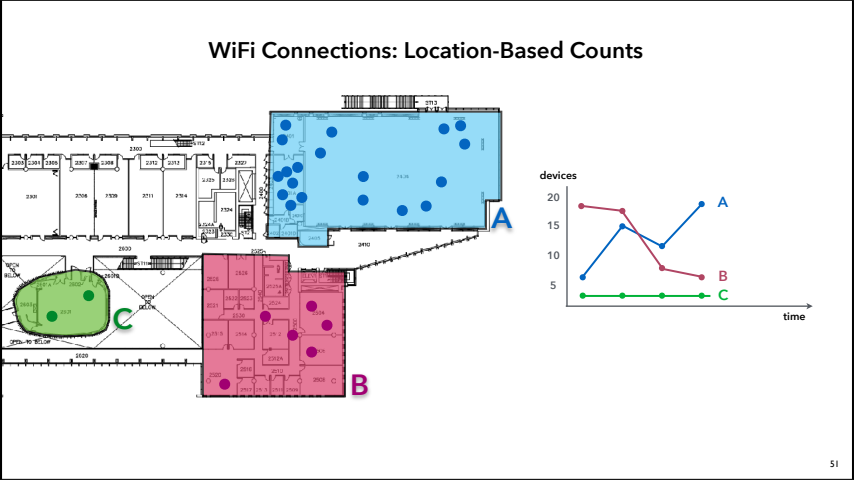
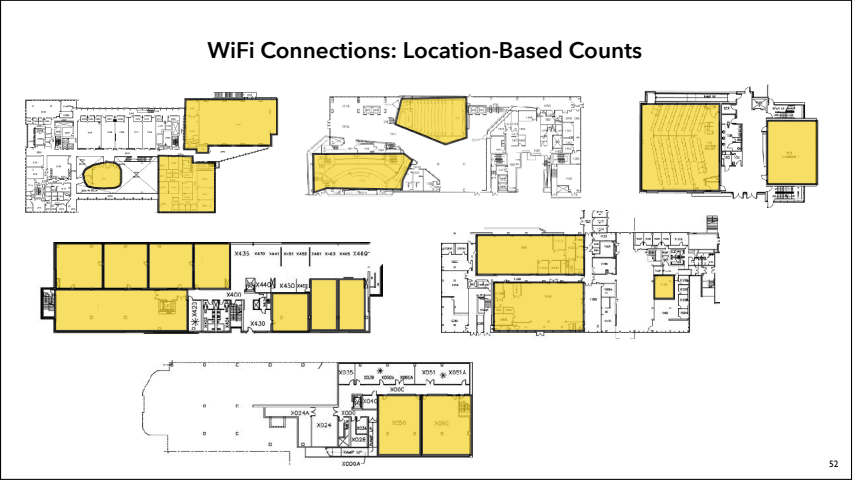
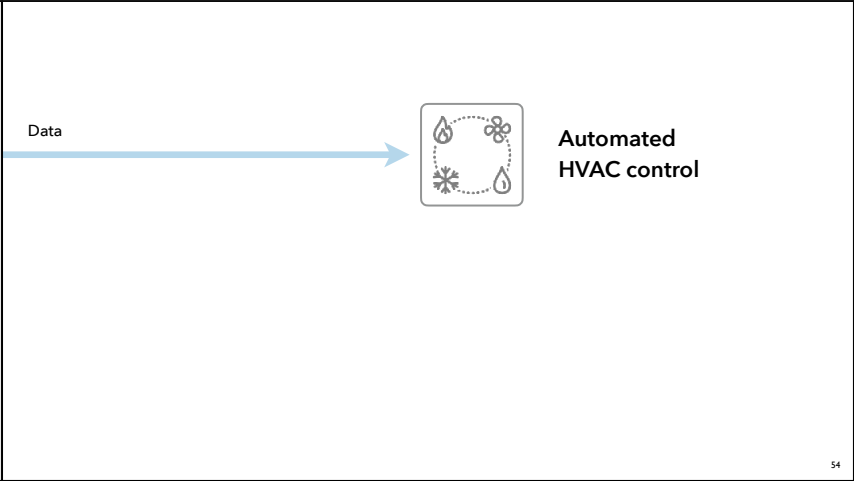
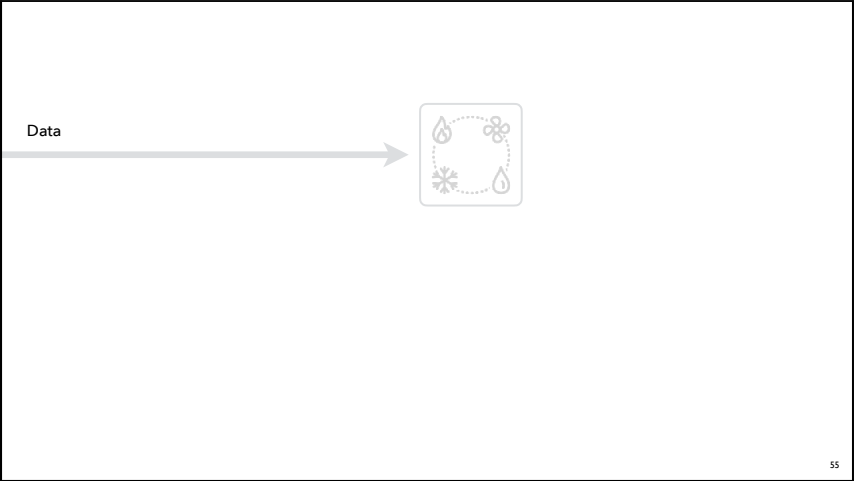
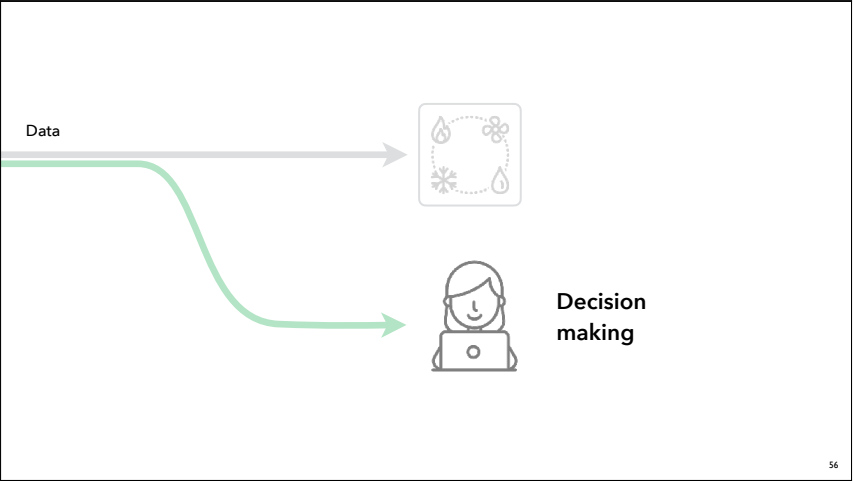
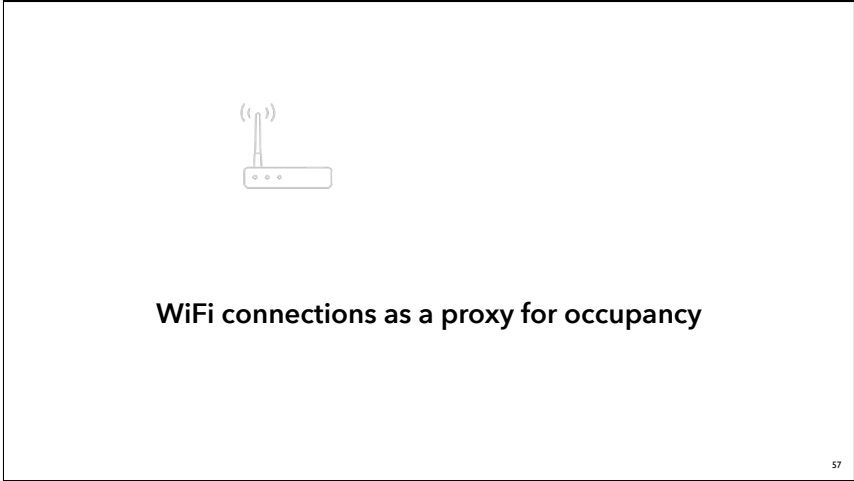
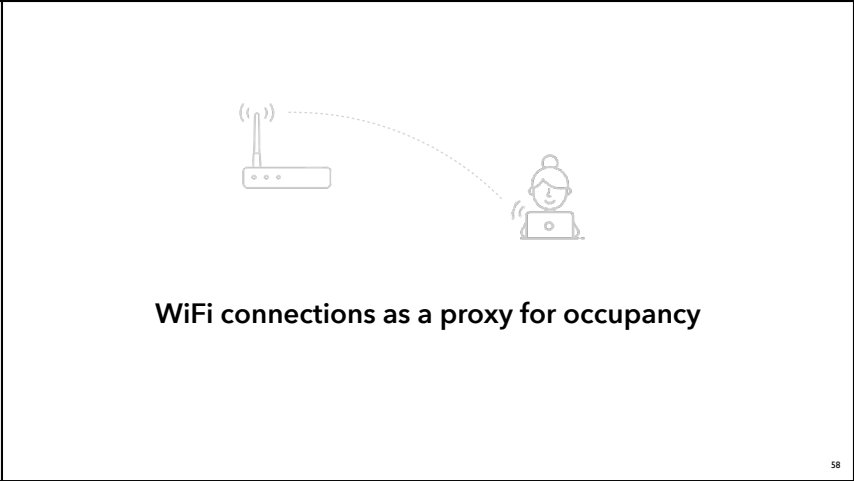




WiFi Connections: Location-Based Counts



WiFi Connections: Location-Based Counts



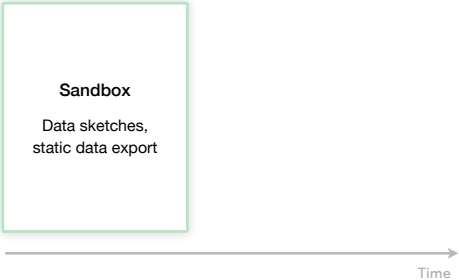
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| <div>WiFi Connections: Location-Based Counts</div>  | <div>WiFi Connections: Location-Based Counts</div>  | <div>WiFi Connections: Location-Based Counts</div>  | <div>WiFi Connections: Location-Based Counts</div>  |
| <div>Location-Based Counts</div> <ul style="list-style-type: none"> Regular intervals (e.g., every 5 minutes) Spatial hierarchy (Zone → Floor → Building → Campus) No trajectories or device identifiers are recorded Intrinsic privacy advantages | <div>Data</div>  <div>Automated HVAC control</div> | <div>Data</div>  | <div>Data</div>  <div>Decision making</div> |
|  <div>WiFi connections as a proxy for occupancy</div> |  <div>WiFi connections as a proxy for occupancy</div> | <div>Interviews with potential stakeholders</div>  | <div>Focus Domains</div> <ul style="list-style-type: none"> Space planning Building management Custodial services Classroom management Data quality control |
| <div>Focus Domains</div> <ul style="list-style-type: none"> Space planning Building management Custodial services Classroom management Data quality control  <div>Semi-structured discussions and live demos</div> | <div>Tasks</div> <ul style="list-style-type: none"> Confirm assumptions or previous observations. Do students occupy room x in evenings or on weekends? | <div>Tasks</div> <ul style="list-style-type: none"> Confirm assumptions or previous observations. Monitor the current/recent utilization rate. Which rooms are empty/busy? | <div>Tasks</div> <ul style="list-style-type: none"> Confirm assumptions or previous observations. Monitor the current/recent utilization rate. Communicate space usage and justify decisions. Space usage improved after renovation. |

Tasks

- ✓ Confirm assumptions or previous observations.
- ✓ Monitor the current/recent utilization rate.
- ✓ Communicate space usage and justify decisions.
- ✓ Validate the data (quality control).
Check minimum size of a room that can be captured.

Spatial and Temporal Data Granularities

Visualization Prototypes



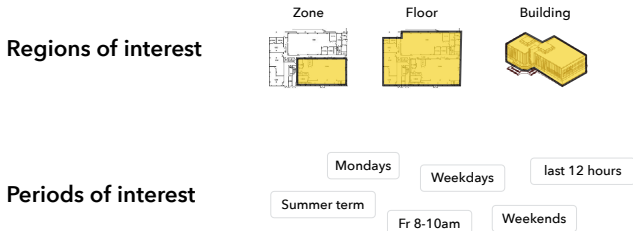
Visualization Prototypes

- original plan: different interface for each stakeholder
- realization: task & data abstractions match multiple stakeholders
 - if slice by space & time granularity

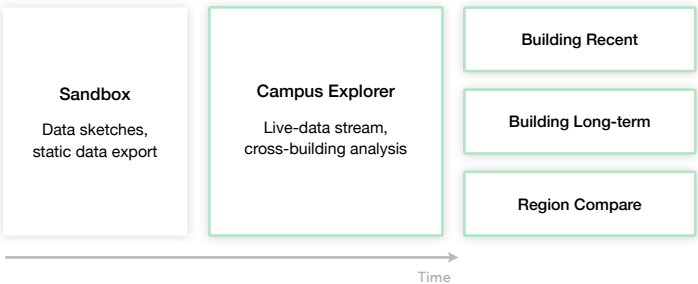
Spatial and Temporal Data Granularities



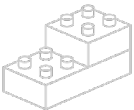
Spatial and Temporal Data Granularities



Visualization Prototypes



Reusable Visualization Components



Reusable Visualization Components

| Layout | Visual Encoding | Facet | Comparisons |
|--------|-----------------|---------------|---|
| | | Juxtaposition | Repeating patterns, trends, outliers (contiguous) |

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| | | Juxtaposition | Repeating patterns, trends, outliers (non-contiguous) |
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| | | Aggregation | Typical utilization profiles |
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| | | Superposition | Within-session patterns, outliers |
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Reusable Visualization Components

| Layout | Visual Encoding | Facet | Comparisons |
|--------|-----------------|---------------|---|
| | | Juxtaposition | Repeating patterns, trends, outliers (contiguous) |

| | | | |
|--|--|---------------|---|
| | | Juxtaposition | Repeating patterns, trends, outliers (non-contiguous) |
|--|--|---------------|---|

| | | | |
|--|--|-------------|------------------------------|
| | | Aggregation | Typical utilization profiles |
|--|--|-------------|------------------------------|

| | | | |
|--|--|---------------|-----------------------------------|
| | | Superposition | Within-session patterns, outliers |
|--|--|---------------|-----------------------------------|

| | | | |
|--|--|---------------|---|
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|--|--|---------------|---|
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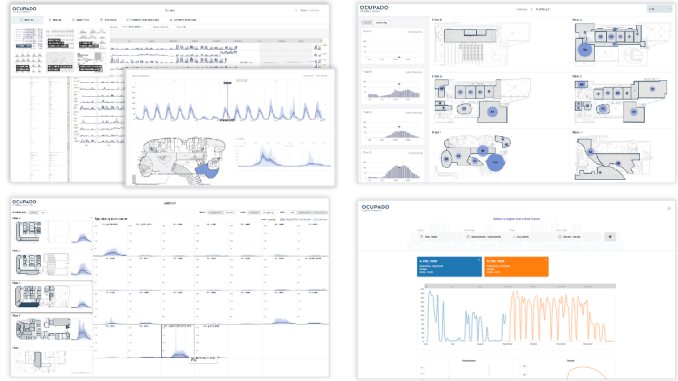
| | | | |
|--|--|-------------|------------------------------|
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|--|--|-------------|------------------------------|

| | | | |
|--|--|---------------|-----------------------------------|
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|--|--|---------------|-----------------------------------|

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| | | | |
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|--|--|---------------|---|

Ocupado Interfaces

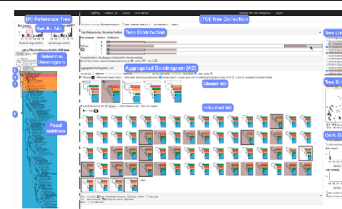


Campus Explorer

- Analysis and abstraction of data and tasks for studying space utilization
- Ocupado, a set of visual decision support tools
- Generalizable design choices for visualizing non-trajectory spatiotemporal data relating to large-scale indoor environments

Two design studies

- facilities management
- biology



Aggregated Dendrograms

for Visual Comparison Between Many Phylogenetic Trees

<http://www.cs.ubc.ca/labs/imager/tr/2019/adview>

Aggregated Dendrograms for Visual Comparison Between Many Phylogenetic Trees.
Liu, Zhan, Munzner. IEEE Trans. Visualization and Computer Graphics (TVCG) 26(9):2732-2747, 2019.



Phylogenetic tree

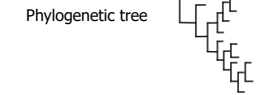
Evolutionary relationships of organisms

Human
Chimpanzee
Macaque

| | | | | | | |
|---|---|---|---|---|---|---|
| A | T | G | G | A | C | A |
| A | T | G | G | A | C | A |
| A | C | G | G | A | C | A |

Genetic information

Computational workflow



Many phylogenetic trees

Human
Chimpanzee
Macaque

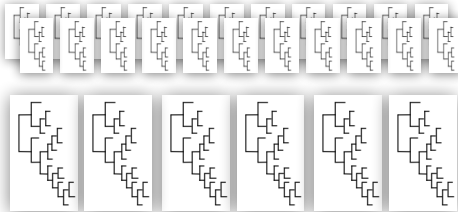
| | | | | | | |
|---|---|---|---|---|---|---|
| A | T | G | G | A | C | A |
| A | T | G | G | A | C | A |
| A | C | G | G | A | C | A |

Genetic information

- Understand relationships between genes and species trees
- Explore trees generated with different methods and data

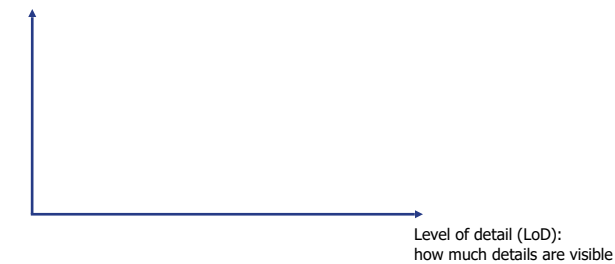
Computational workflow

Phylogenetic tree



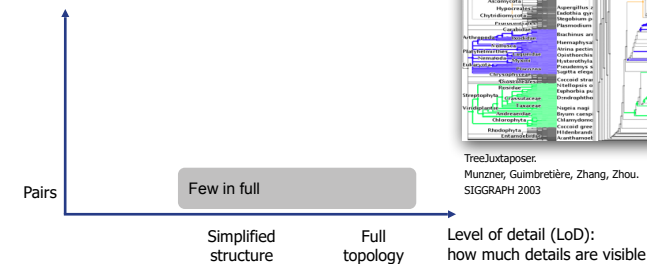
Scalability of Existing Tree Comparison Systems

#Trees: how many trees to compare



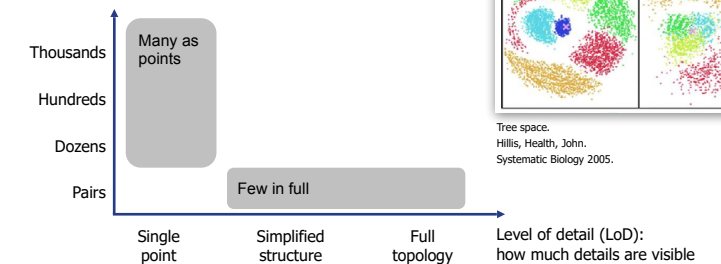
Scalability of Existing Tree Comparison Systems

#Trees: how many trees to compare



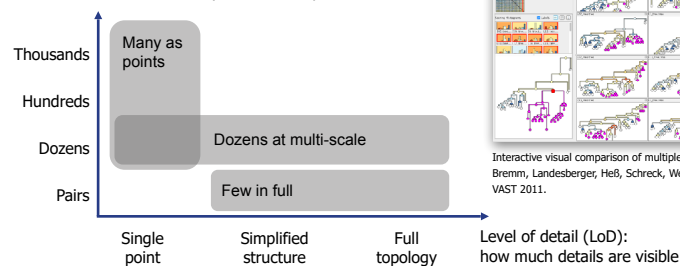
Scalability of Existing Tree Comparison Systems

#Trees: how many trees to compare



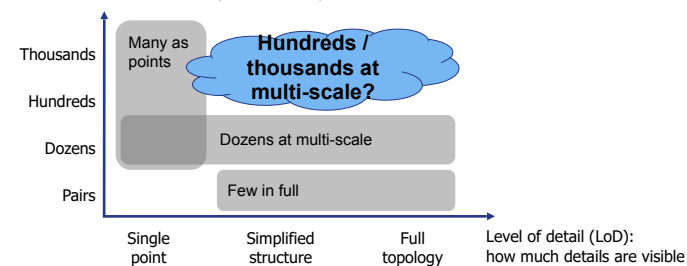
Scalability of Existing Tree Comparison Systems

#Trees: how many trees to compare



Comparing many phylogenetic trees

#Trees: how many trees to compare

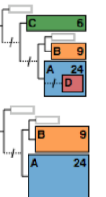


Contributions include idiom & algorithm levels

- Data and task abstractions for comparison of phylogenetic trees

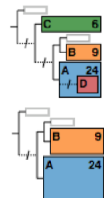
Contributions include idiom & algorithm levels

- Data and task abstractions for comparison of phylogenetic trees
- A new visual encoding: **Aggregated Dendrogram**
 - Compact tree representation that focuses on selected subtrees
 - Adapts to available screen space



Contributions include idiom & algorithm levels

- Data and task abstractions for comparison of phylogenetic trees
- A new visual encoding: **Aggregated Dendrogram**
 - Compact tree representation that focuses on selected subtrees
 - Adapts to available screen space
- A multi-view interactive tool: **ADView**
 - Covers multiple levels of details for tree comparison



Data & Tasks

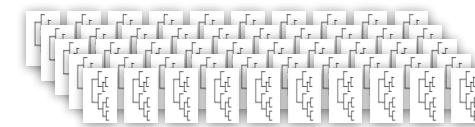
- Tree data
- Two crucial tasks

Tree data

Reference tree

vs.

Tree collection

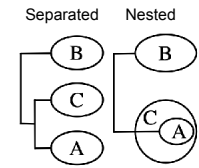


Two crucial tasks

Topological relationships between subtrees / leaf nodes

Two crucial tasks

Topological relationships between subtrees / leaf nodes

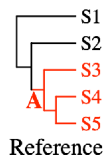
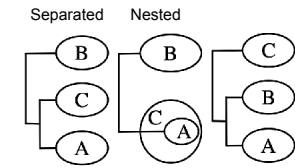


Two crucial tasks

Topological relationships between subtrees / leaf nodes

- Topological distance

Leaf node memberships compared to reference tree

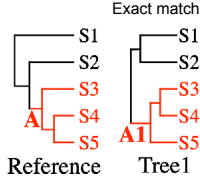
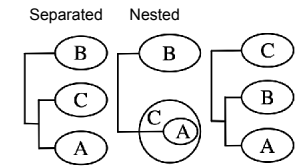


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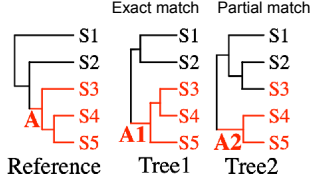
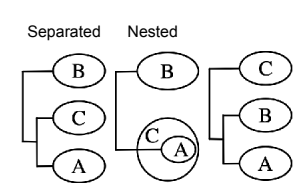


Two crucial tasks

Topological relationships between subtrees / leaf nodes

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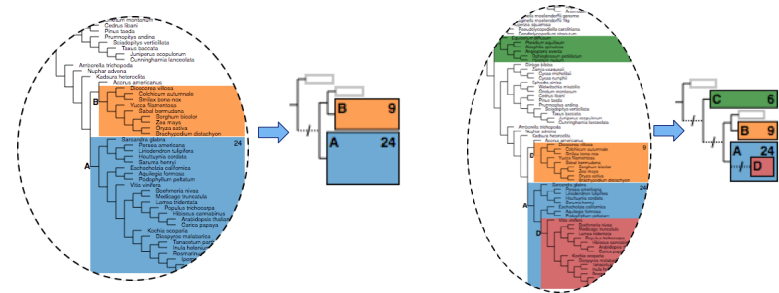


Aggregated Dendrogram (AD)

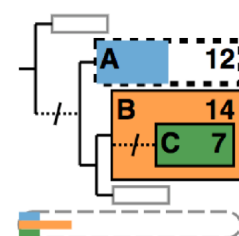
- Intuition
- Visual design

Intuition

Use glyphs to compress a tree according to user selections

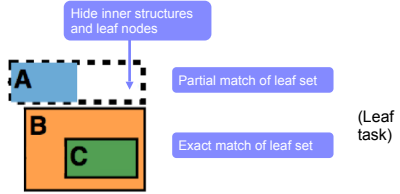


Visual design: focus + context



Visual design: focus + context

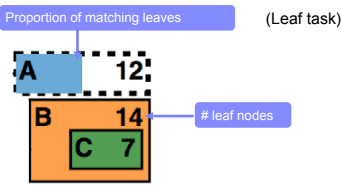
- Focus
 - Selected subtrees



(Leaf task)

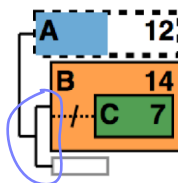
Visual design: focus + context

- Focus
 - Selected subtrees



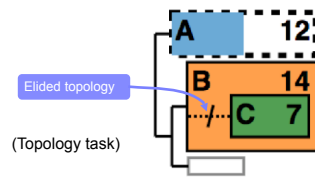
Visual design: focus + context

- Focus
 - Selected subtrees
 - Topological relationships between them



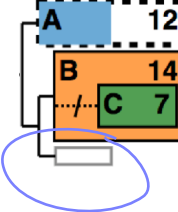
Visual design: focus + context

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 - Topological relationships between them



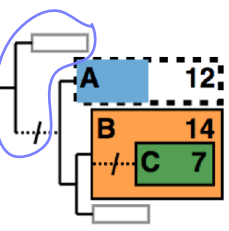
Visual design: focus + context

- Focus
 - Selected subtrees
 - Topological relationships between them
- Context
 - Neighboring subtrees



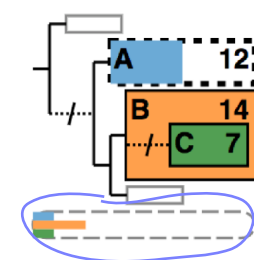
Visual design: focus + context

- Focus
 - Selected subtrees
 - Topological relationships between them
- Context
 - Neighboring subtrees
 - Upstream topology and root



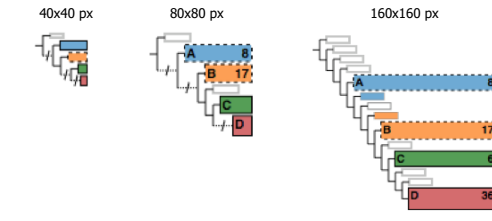
Visual design: focus + context

- Focus
 - Selected subtrees
 - Topological relationships between them
- Context
 - Neighboring subtrees
 - Upstream topology and root
 - Missing leaf nodes



Visual design: algorithm adapts to space

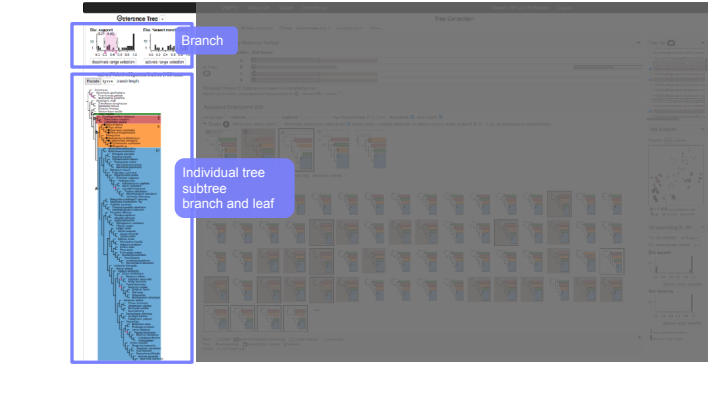
- Show more info when space permitted
 - Labels
 - #leaf nodes
 - Neighboring blocks



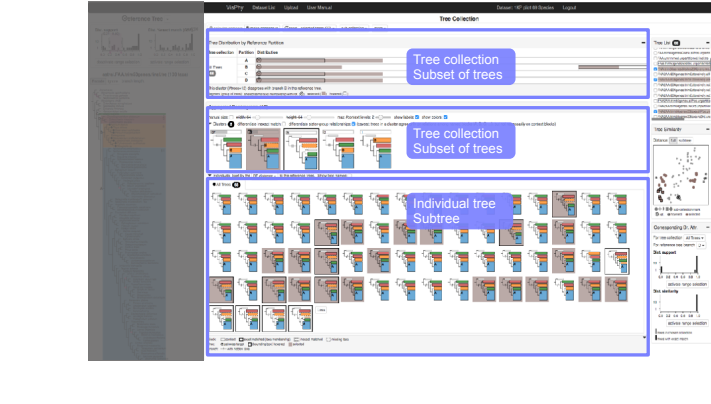
ADView Interface: Multi-level structure across views



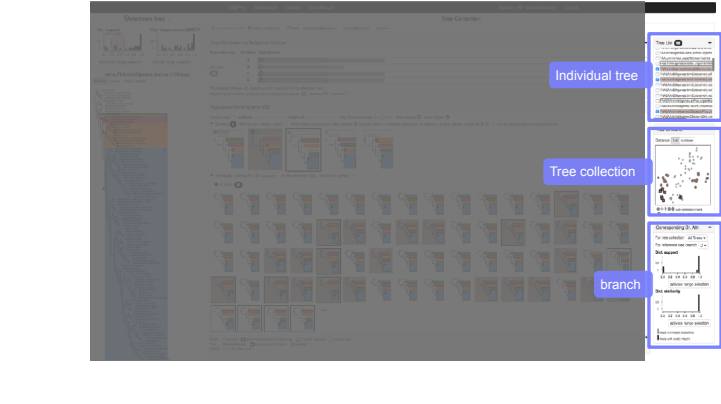
Multi-level structure across views



Interface walkthrough: tree collection main views



Interface walkthrough: tree collection aux. views



Aggregated Dendrograms for Visual Comparison between Many Phylogenetic Trees

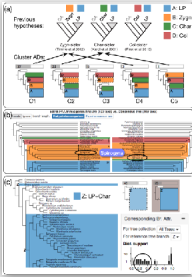
Zipeng Liu, Shing Hei Zhan, Tamara Munzner

Validation with many biologists

- Work closely with a biology PhD student (second author)
- Demos, interviews and discussions
 - 10 biologists at different times throughout project

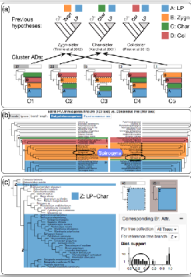
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- User study sessions
 - 5 biologists
 - Using their own datasets



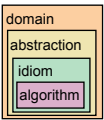
Validation with many biologists

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- User study sessions
 - 5 biologists
 - Using their own datasets
- Biologists confirmed
 - Validity of data and task abstractions
 - Utility of ADView



Problem-driven visualization through design studies

- methodology matters
 - identify abstractions
 - crucial & difficult, iterative process
 - select appropriate idioms
 - or create new ones if necessary



- two examples
 - different domains
 - different methods



imperfect models

One case study of visualizing imperfect models

- NLP for temporal data



TimeLineCurator

Interactive Authoring of Visual Timelines from Unstructured Text

<http://about.timelinecurator.org>
<http://timelinecurator.org>

TimeLineCurator: Interactive Authoring of Visual Timelines from Unstructured Text.
Fulda, Brehmer, Munzner. IEEE Trans. Visualization and Computer Graphics (Proc. IEEE VAST 2015) 22(1):300-309, 2015.

Johanna Fulda
@jofu

Matthew Brehmer
@mattbrehmer

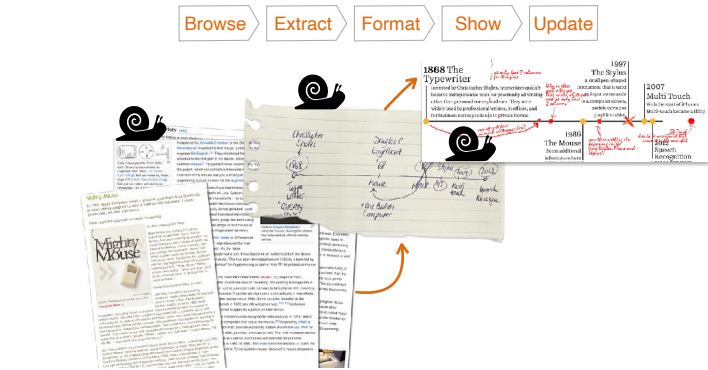
Tamara Munzner
@tamaramunzner

TimeLineCurator

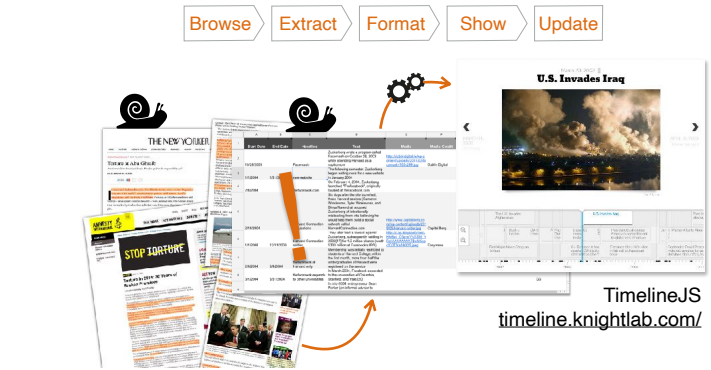
visual & browser-based

<https://vimeo.com/jofu/tlc>

Manual creation process



Structured creation process



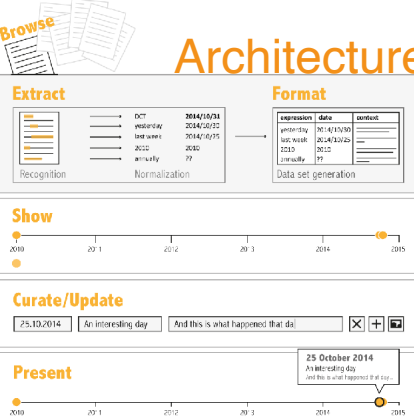
Timeline authoring model

- time required for each task

| | Browse | Extract | Format | Show | Update |
|---------------------|--------|-----------|-----------|-----------|--------|
| Manual Drawing | slow | slow | slow | slow | slow |
| Structured Creation | slow | slow | slow | automated | fast |
| TimeLine Curator | fast | automated | automated | fast | fast |

The general case for curation

- build for human in the loop as continuing need
 - automatic processing to accelerate not replace
 - **assume computational results good but not perfect**
 - for the indefinite future!
 - visual feedback to accelerate



The importance of being brisk

- cool use case: eureka moment
 - success: enable what was impossible before
 - vis tools for new insights & discoveries
- workhorse use case: workflow speedup
 - success: vis tools accelerate your prior workflow
 - sometimes enables the previously infeasible



- TLC use cases
 - started with speedup use case, for presentation
 - make this doc into a timeline now!
 - two other use cases nudge towards exploration
 - comparison between multiple timelines
 - speculative browsing

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TimeLineCurator: Speculative Browsing



<https://vimeo.com/jofu/tlc>

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Q&A

Come talk!

- encourage meeting with me to get advice/feedback before final present
 - chance to get feedback while you can still act on it
 - optional, not mandatory
 - wise to schedule in advance by email
 - can't meet with all 14 teams in next week office hours, or in last few days!

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