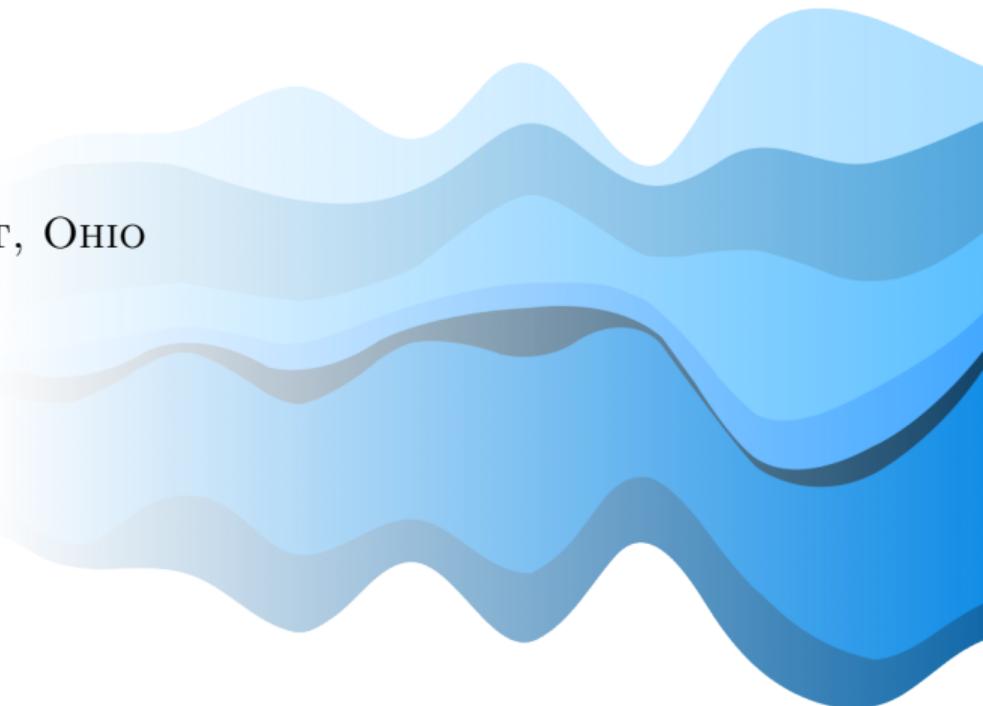


VAST CHALLENGE 2022

PATTERNS OF LIFE IN ENGAGEMENT, OHIO
DATA VISUALIZATION

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Tommaso Crippa
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December 2025



Challenge Overview

The Problem

Challenge Overview

Urban Planning Challenge

- City of Engagement, Ohio
- Low knowledge of resident behavior
- Need data-driven insights

Challenge Scope

- Map of urban area
- 15 months of data
- Diverse activity patterns

Our Mission

- Analyze patterns of daily life
- Identify city characteristics
- Support infrastructure planning
- Improve quality of life

The Dataset

Challenge Overview

Massive Urban Activity Data

- **Duration:** 15 months (March 2022 - May 2023)
- **Participants:** ~1,000 volunteer residents
- **Data Volume:** ~18GB of location and activity logs
- **Sampling Rate:** Every 5 minutes, 24/7

Data Sources

- **Participant Status:** Location, activity mode, joviality
- **Buildings:** Venue types, locations, polygons
- **Travel Journal:** Trip origins, destinations, purposes
- and more...

Challenge: Transform raw data into actionable urban insights

Research Questions

Challenge Overview

1. **Question 1:** What are the distinct areas of the city?
2. **Question 2:** Where are the traffic bottlenecks?
3. **Question 3:** How do individual daily routines differ?
4. **Question 4:** How do patterns change over time?

Our Solution

Technology Stack

Our Solution

Frontend

- React + TypeScript + Vite
- D3.js for interactive visualizations

Backend

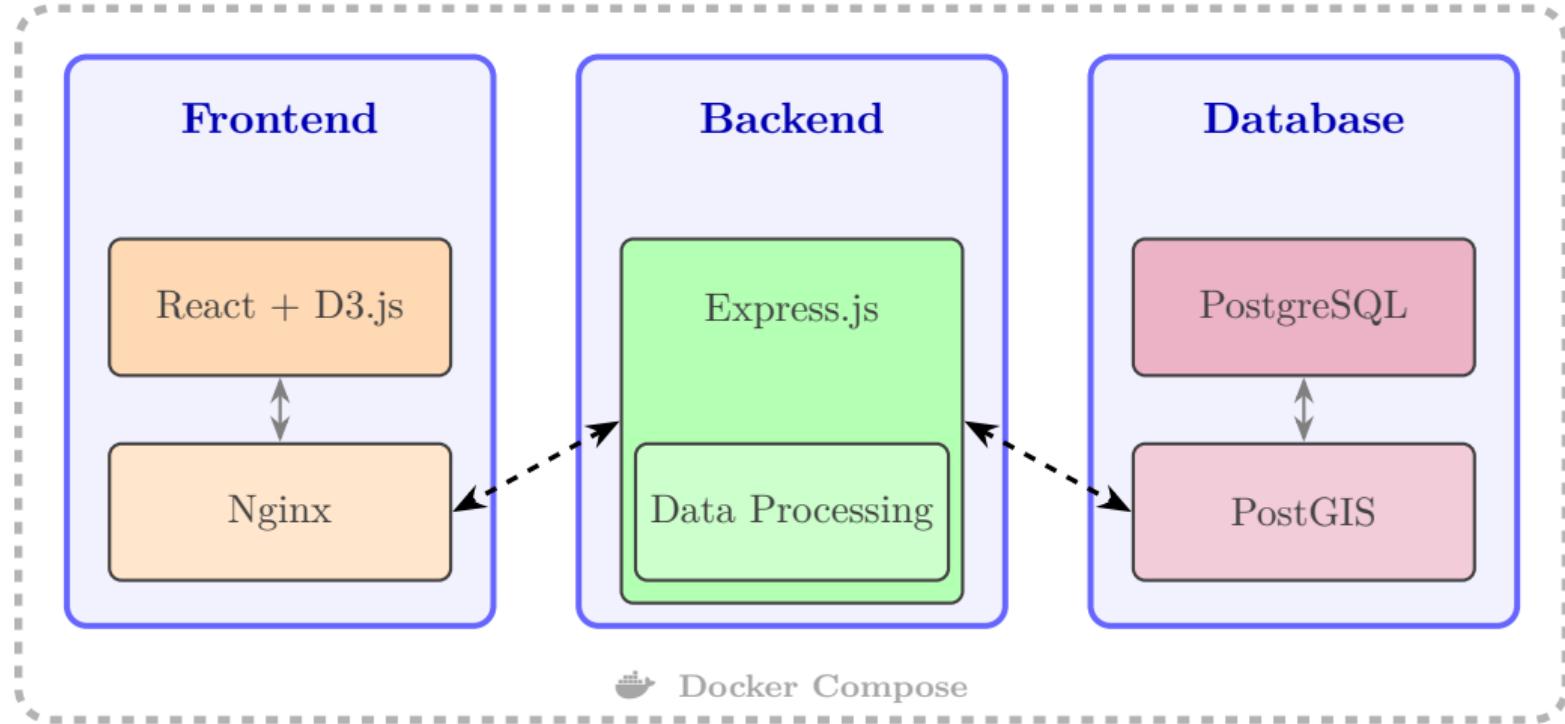
- Node.js + Express
- PostgreSQL with PostGIS

Deployment

- Docker containerization for all services
- Nginx reverse proxy for API routing
- Optimized database with materialized views

Architecture Overview

Our Solution

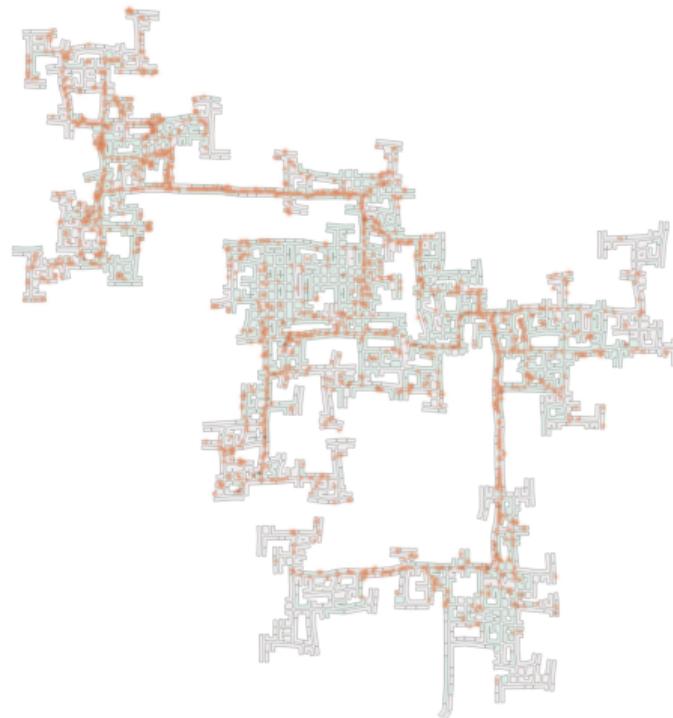


Visualization Techniques

How can we identify
activity hotspots
across the city?

Visualization 1: Spatial Heatmap

Visualization Techniques



Spatial Heatmap - Purpose & Features

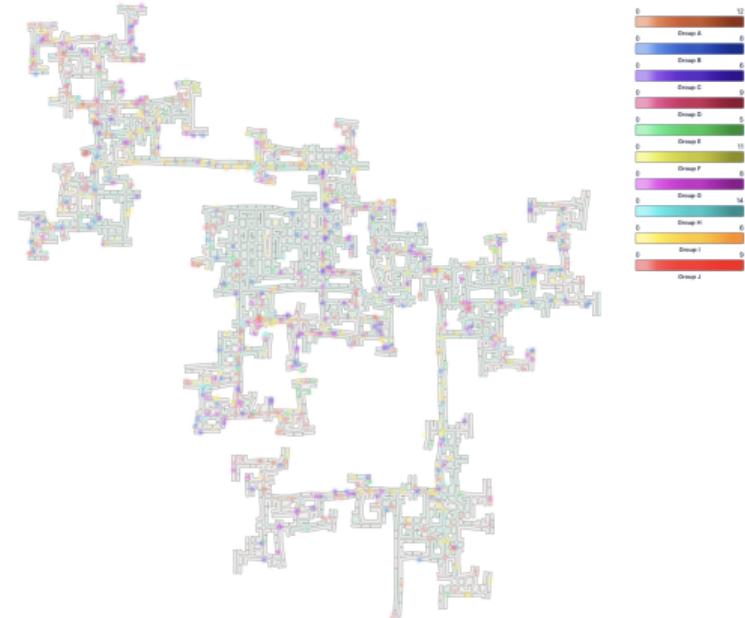
Visualization Techniques

Purpose

- Visualize activity density across the city
- Identify busy areas and hotspots
- Track temporal patterns

Key Features

- Grid-based aggregation
- Time slider (hourly/daily/weekly)
- Interest Group filtering
- Building polygon overlay



Spatial Heatmap - Evaluation

Visualization Techniques

Pros

- Intuitive geographic representation
- Reveals spatial patterns at a glance
- Flexible temporal exploration
- Supports multiple aggregation levels
- Combines well with building overlays
- Effective for identifying hotspots

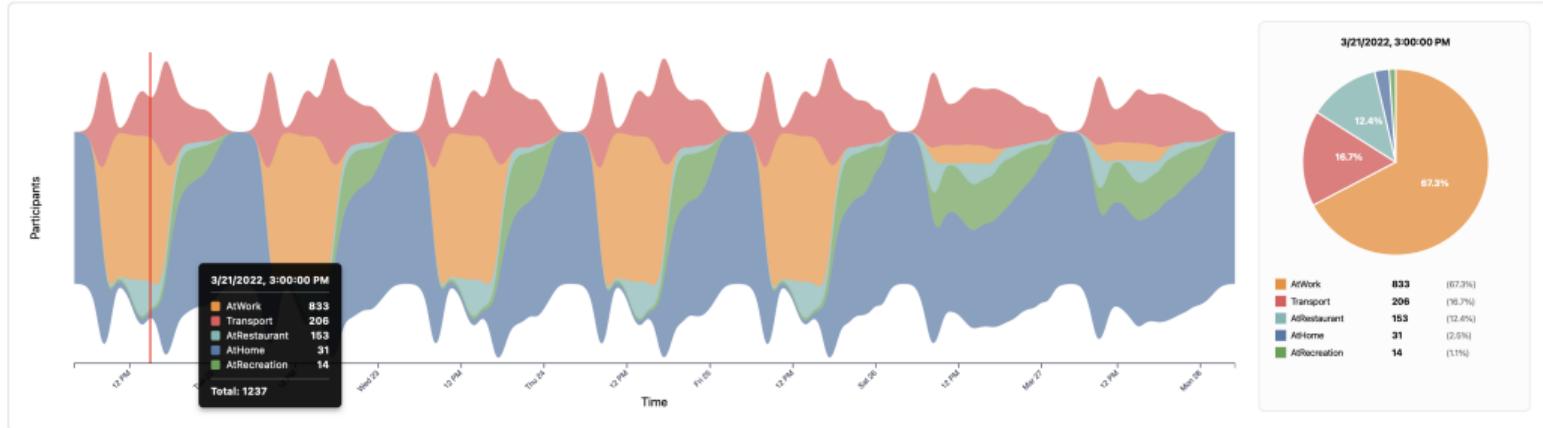
Cons

- Grid resolution affects interpretation
- Can obscure individual movements
- Performance challenges with high granularity
- Requires spatial context to interpret
- May hide temporal variations within aggregates

How do activity patterns evolve over time?

Visualization 2: Activity Streamgraph

Visualization Techniques



Activity Streamgraph - Purpose & Features

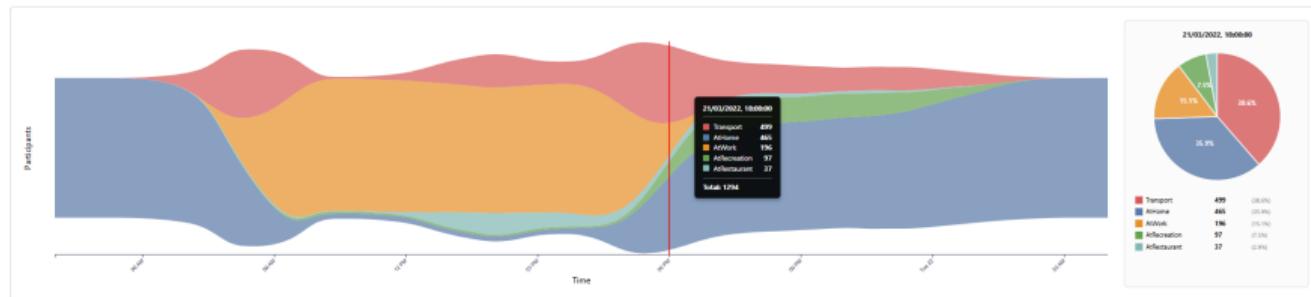
Visualization Techniques

Purpose

- Show activity distribution and normalization over time
- Reveal behavioral shifts
- Track participation trends

Key Features

- Stacked area chart with smooth interpolation
- Multiple activity types (work, social, etc.)
- Temporal filtering capabilities
- Color-coded activity categories



Activity Streamgraph - Evaluation

Visualization Techniques

Pros

- Shows composition and trends simultaneously
- Engaging
- Reveals both macro and micro patterns
- Effective for time-series comparison
- Handles multiple categories elegantly

Cons

- Difficult to read precise values
- Thin layers harder to interpret
- Can be overwhelming with longer date ranges
- Requires color differentiation
- Temporal aggregation may hide short-term spikes

How do individual
daily routines differ?

Visualization 3: Activity Calendar

Visualization Techniques



Activity Calendar - Purpose & Features

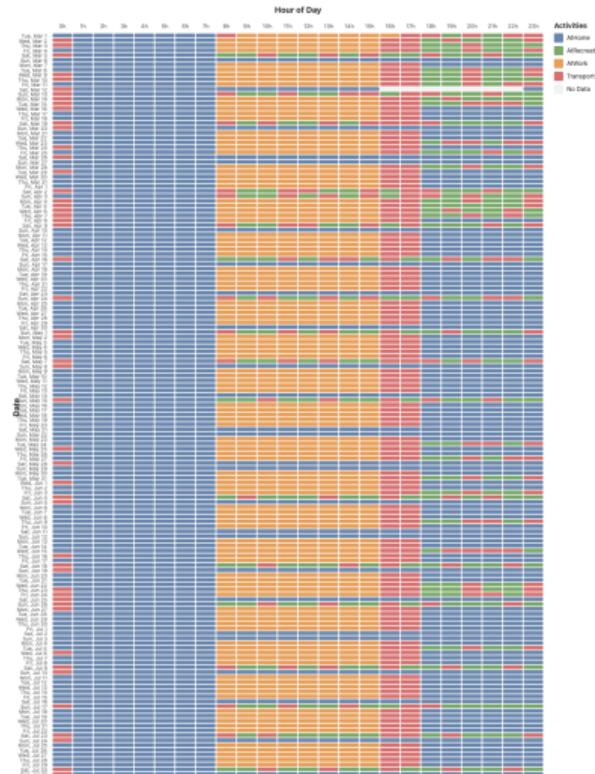
Visualization Techniques

Purpose

- Analyze individual daily routines
- Identify patterns and variations

Key Features

- Days × Hours matrix
- Color-coded by activity type
- Scrollable timeline for full 15-month or smaller periods



Activity Calendar - Evaluation

Visualization Techniques

Pros

- Compact representation of long periods
- Patterns emerge naturally (work hours, weekends)
- Easy to spot anomalies and changes
- Effective for individual analysis
- Supports direct comparison
- Intuitive time-of-day interpretation

Cons

- Limited to individual
- Requires significant screen space
- Can be cluttered with too many activity types
- Doesn't show spatial information
- Difficult to see population-level trends

How can we compare individual lifestyles?

Visualization 4: Participant Comparison

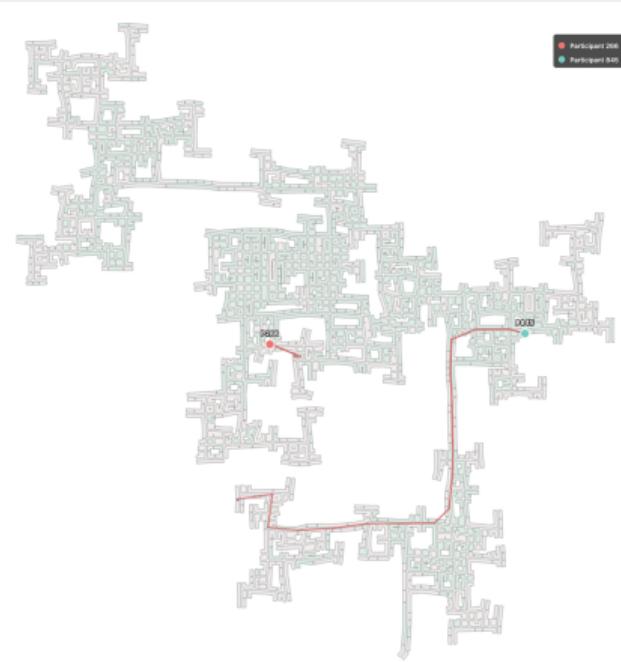
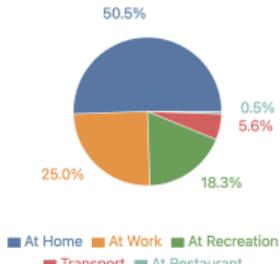
Visualization Techniques

Participant 266

Age: 32 years Household: 3 people
 Children: Yes Education: Graduate Degree
 Interest Group: F Joviality: 97.3%

Distance Travelled:
158.75 units

Activity Distribution

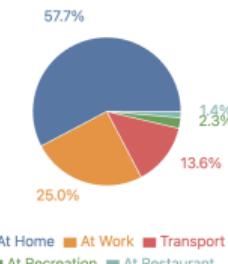


Participant 845

Age: 40 years Household: 2 people
 Children: No Education: High School/College
 Interest Group: G Joviality: 23.5%

Distance Travelled:
501.16 units

Activity Distribution



Participant Comparison - Purpose & Features

Visualization Techniques

Purpose

- Compare individual behavioral patterns
- Identify contrasting lifestyles
- Support hypothesis about proximity and well-being

Key Features

- Daily travel distance
- Average joviality score
- Social activity percentage
- Work patterns
- Demographics

Participant Comparison - Evaluation

Visualization Techniques

Pros

- Direct quantitative comparison
- Reveals individual differences
- Supports finding extreme cases
- Evidence-based storytelling

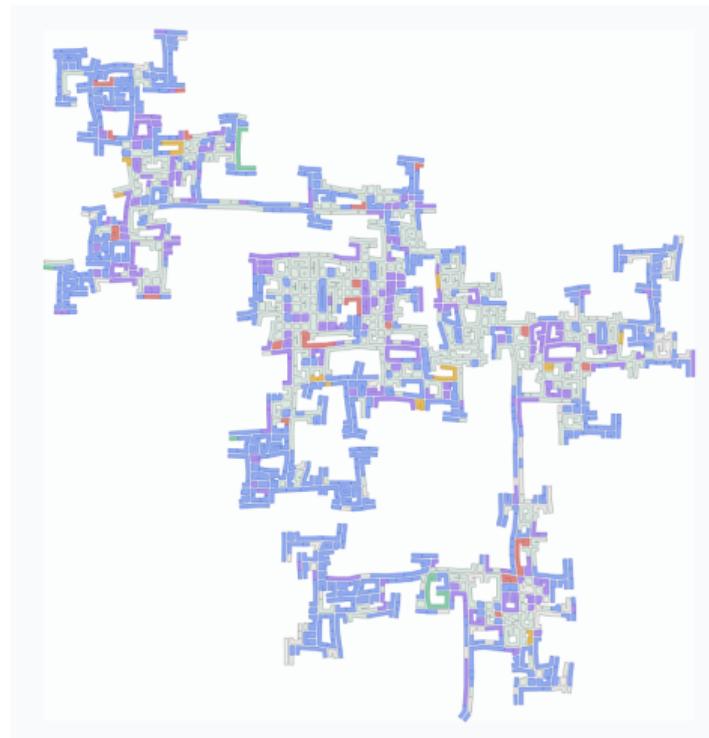
Cons

- Limited to 2 participants at once
- Doesn't show population distribution
- Risk of cherry-picking examples
- Requires manual selection

How can we understand
urban infrastructure context?

Visualization 5: Building Polygons Overlay

Visualization Techniques



Building Polygons - Purpose & Features

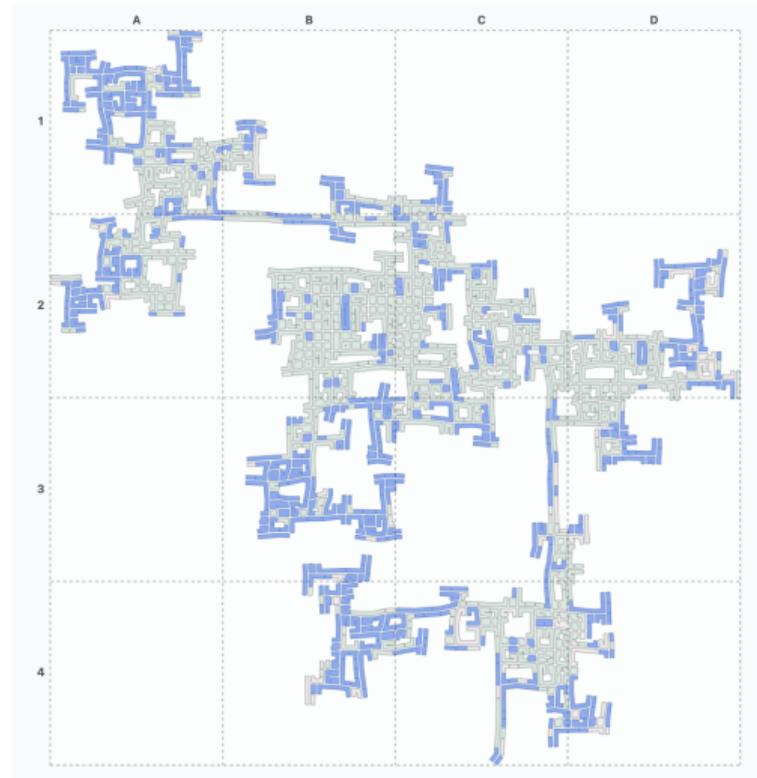
Visualization Techniques

Purpose

- Provide spatial context for activity patterns
- Link activities to physical infrastructure
- Identify functional zones

Key Features

- Filter by building type
- Dynamic coordinates grid
- Color-coded by function



Building Polygons - Evaluation

Visualization Techniques

Pros

- Connects activity to infrastructure
- Helps explain spatial patterns
- Supports urban planning decisions
- Reveals functional zoning
- Combines well with other visualizations

Cons

- Requires accurate building data
- Static representation of spaces

Reflection

Strengths & Limitations

Reflection

Strengths

- Interactive exploration
- Multi-scale analysis
- Evidence-based insights
- Scalable architecture
- Accessible visualizations

Limitations

- Sample representativeness
- No causal analysis
- Performance constraints
- Learning curve

Conclusion

Lessons Learned

Conclusion

Technical Insights

- PostGIS is essential for scalable spatial queries
- Server-side aggregation beats client-side processing for massive datasets
- Strategic data preprocessing dramatically improves query performance
- Data quality directly impacts analytical reliability

Design Insights

- Multiple perspectives unlock complementary insights
- Context integration across visualizations amplifies understanding
- Interactive tools empower discovery of hidden patterns
- Dual views, individual and aggregate, answer different questions

Work division

Conclusion

Alberto Finardi

- Infrastructure development
- Backend & Frontend boilerplate
- Heatmap implementation
- Streamgraph implementation

Tommaso Crippa

- Calendar implementation
- Comparison implementation
- Video production
- UI Cleanup

Tom Gave

- Building polygons implementation

Thank You!

Questions?

Alberto Finardi Tommaso Crippa Tom Gave