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VAST Challenge 2022

Patterns of Life in Engagement, Ohio
Data Visualization

Alberto Finardi
Tommaso Crippa
Tom Gave

December 2025

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Challenge Overview

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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

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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

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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?

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Our Solution

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Visual Analytics Platform

Our Solution

Technology Stack

Frontend

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

Backend

- Node.js + Express
- PostgreSQL with PostGIS

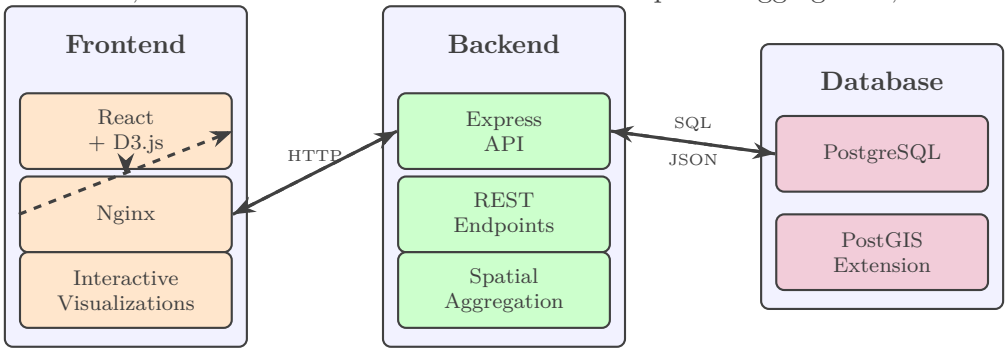
Deployment

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

Architecture Overview

Our Solution

FIX THIS, remove Interactive Visualizations and Spatial Aggregation, fix lines



Dockerized deployment with Nginx reverse proxy for API routing

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Visualization Techniques

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How can we identify activity hotspots across the city?

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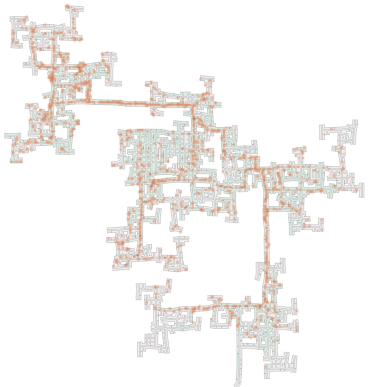
Visualization 1: Spatial Heatmap

Visualization Techniques



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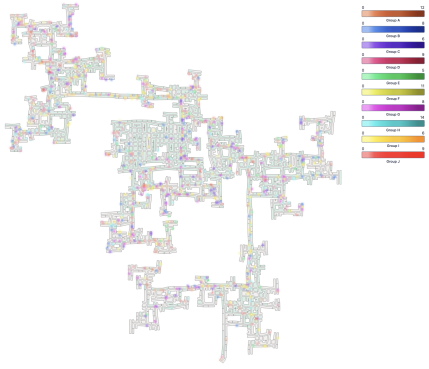
Spatial Heatmap - Purpose & Features

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
- Interactive zoom and pan

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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

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How do activity patterns evolve over time?

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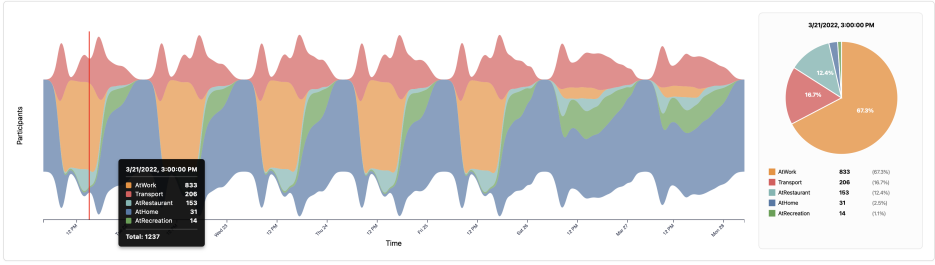
Visualization 2: Activity Streamgraph

Visualization Techniques



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Activity Streamgraph - Purpose & Features

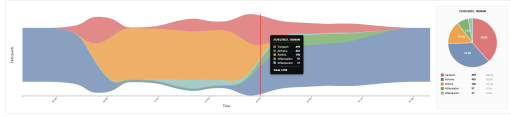
Visualization Techniques

Purpose

- Show activity percentage 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



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Activity Streamgraph - Evaluation

Visualization Techniques

Pros

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

Cons

- Difficult to read precise values
- Middle layers harder to interpret
- Can be overwhelming with too many categories
- Requires color differentiation
- Temporal aggregation may hide short-term spikes

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How do individual daily routines differ?

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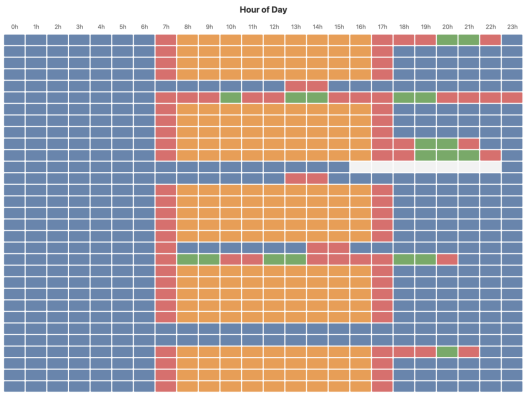
Visualization 3: Activity Calendar

Visualization Techniques



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Activity Calendar - Purpose & Features

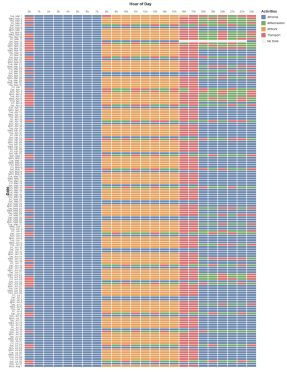
Visualization Techniques

Purpose

- Analyze individual daily routines
- Identify patterns and variations
- Compare participants side-by-side

Key Features

- Days × Hours matrix
- Color-coded by activity type
- One month visible at a glance
- Scrollable timeline for full 15-month period



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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

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How can we understand urban infrastructure context?

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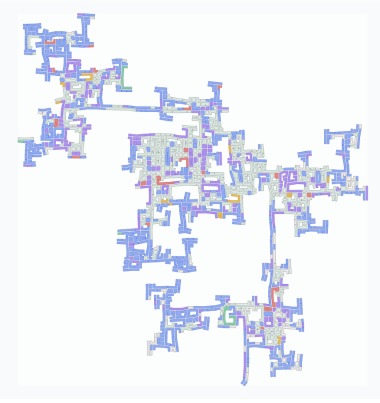
Visualization 4: Building Polygons Overlay

Visualization Techniques

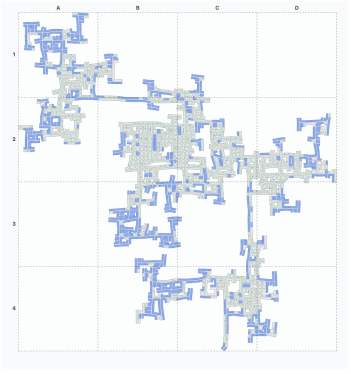


Building Polygons - Purpose & Features

Visualization Techniques

Purpose

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



Key Features

- Filter by building type
- Integrated with heatmap for layered context
- Color-coded by function

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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

- Can clutter the map
- Requires accurate building data
- May obscure underlying heatmap
- Static representation of dynamic spaces

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How can we compare individual lifestyles?

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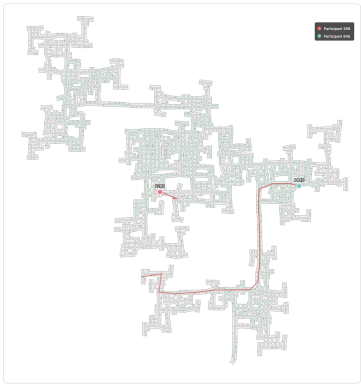
Visualization 5: Participant Comparison

Visualization Techniques



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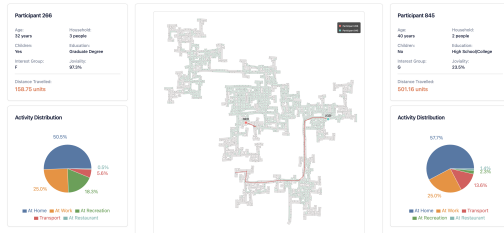
Participant Comparison - Purpose & Features

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

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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

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Data Aggregation Strategy

Visualization Techniques

Spatial Aggregation

- Grid-based binning (configurable cell size)
- `GROUP BY FLOOR(lat/cell_size), FLOOR(lng/cell_size)`
- Enables density calculation and hotspot identification

Temporal Aggregation

- Hourly: Daily patterns and rush hours
- Daily/Weekly: Routine identification
- Monthly: Long-term trends

Activity Mode Filtering

- Work, Home, Restaurant, Pub, Recreation, School, Shopping
- Supports focused analysis by activity type
- Reveals functional zones in the city

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Reflection

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Strengths & Limitations

Reflection

Strengths

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

Future Enhancements

- Flow diagrams
- Speed heatmaps
- Predictive modeling
- Real-time integration

Limitations

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

Applicability

- Urban planning
- Transportation analysis
- Behavioral studies
- Decision support

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Key Takeaways

Reflection

1. **PostGIS essential** for spatial data
2. **Iterative design** reveals insights
3. **Performance matters** for 18GB datasets
4. **Context drives interpretation**
5. **Visual analytics** enables discovery

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Conclusion

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Summary: Challenge Accomplished

Conclusion

Answered All Four Questions

1. **City Areas:** 3 distinct zones identified
2. **Bottlenecks:** 3 critical congestion points
3. **Routines:** 6× difference in commute impacts life
4. **Changes:** 10 temporal patterns documented

Delivered actionable urban planning insights through interactive visual analytics

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Thank You!

Questions?

Alberto Finardi Tommaso Crippa Tom Gave