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Detecting Human Flow Surges to Identify Event-Driven Activation in a Small City

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Introduction

Small cities in Japan are facing population decline and economic stagnation. Events are considered a potential tool to revitalize urban centers. This study aims to identify which events lead to significant changes in human flow, as a first step to modeling event-driven urban activation.

Dataset

- Data Source: Anonymized GPS data collected from approximately 340 volunteer participants in Takehara City over two years (2023–2024).
- Preprocessing:1. Trip extraction (OD movement per user); 2. Only trips with destinations located within Takehara City were retained for analysis.
- Spatial Unit: 100m × 100m grid covering the central urban area

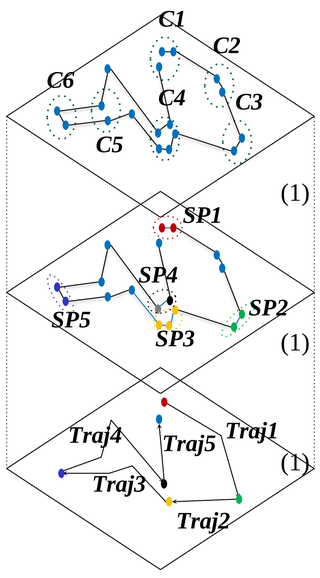

Figure 1:Trip Abstraction

Methodology

- Step 1 Daily Flow Mapping: Mapping unique users arriving in each grid per day.
- Step 2 Z-Score Normalization of Grid-Level Flow: To identify unusual spikes in flow, a Z-score was calculated for each grid cell using a 30-day moving window:

$$Z_{i,t} = \frac{X_{i,t} - \mu_{i,t}}{\sigma_{i,t} + \epsilon}$$

Where $X_{i,t}$ is the mapped inflow value to grid cell i on day t, $\mu_{i,t}$ and $\sigma_{i,t}$ represent the mean and standard deviation of inflow over the 30-day window centered at t, and ϵ is a small constant to prevent division by zero.

- Step 3 A day is selected as a candidate event day if it contains at least one grid cell where:

$$Z_{i,t} > 3 \;\&\; X_{i,t} > 5$$

- Step 4: For all candidate days, a global Z-score is computed based on the number of abnormal grid cells. Days with significantly high Z-scores are identified as the final event days and conduct cross-referenced with the official city event calendar.

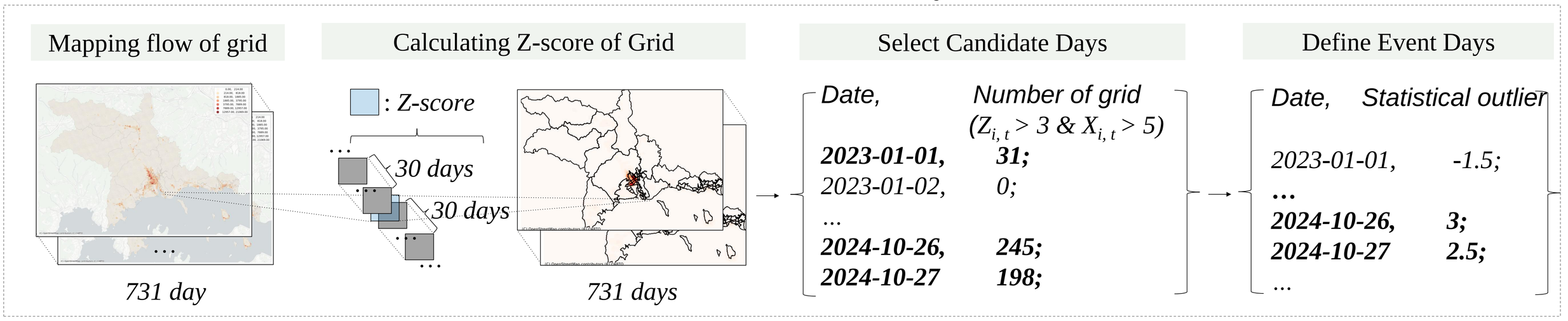

Figure 2: Workflow for Detecting Event-Driven Human Flow Surges Using Grid-Based Z-Score and Statistical Outlier Detection

Result & conclusion

- Validation of days with positive deviation values showed good correspondence with known local events (see right). This suggests that the spatial surge in human flow detected via Z-score–based hotspot extraction is not random, but likely driven by organized activities. The results confirm the method's effectiveness in identifying impactful event days. This approach provides a robust foundation for subsequent analyses on how specific events influence the spatial and temporal patterns of human mobility in small cities.

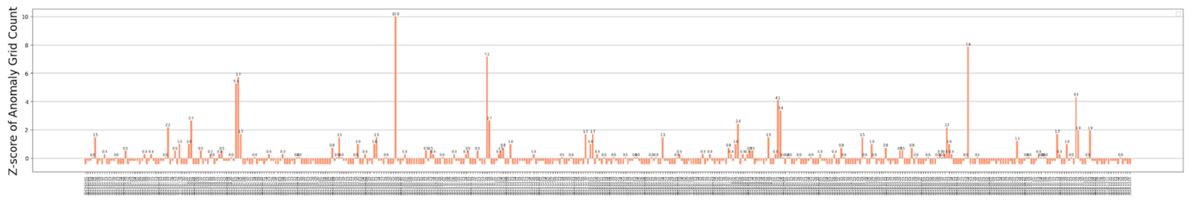

Figure 3: Standardized deviation

Date	Event	Deviation
2023-02-05	たけはら“まち”あいマルシェ；第４５回竹原ロードレース大会	**1.5**
2023-02-11 〜2023-03-21	第17回 たけはら町並み雛めぐり	0.3; 0.5; 0.3; 0.3; **2.2**
2023-04-01/02	幵学；パンプーお花見デー	**1.0**; **2.7**
2023-04-10	竹原市立竹原西小学校入学式 竹原市立竹原中学校入学式	0.5
2023-04-15/16	忠海床祭り	0; 0.3
2023-04-22/23	桃ねこ様祭り	0.3; 0.5
2023-05-03~05	竹祭り	**5.3; 5.7**; **1.7**
2023-05-14	つなぐ！第3回わんぱく相撲広島県大会竹原場所	0
2023-05-25	竹原市観光協会令和5年度第10回定時総会	0.3
2023-06-03/04	忠海ゆかたまつり	0.3
2023-07-08	七夕祭り	0.8
2023-07-16/17	忠海祇園祭	0; **1.5**
2023-07-29/30	住吉祭り	0; **1.0**
2023-08-12/13	吉和花火大会	**1.0; 1.5**
2023-08-26	竹原花火大会	**10**
2023-09-02	たびにいこうぜ。せとうち「ひろしま」	0.3
2023-09-23/24	「竹取物語 光るKIMONO十二単」＆「冨田伸明が手掛けた衣装展」in 竹原	0.5; 0.3
2023-10-08	第４８回竹原市民大会（長距離の部）	0.3
2023-10-15	ミニラグビー体験会	0.5
2023-10-21	Smile park	0.5
2023-10-28/29	憧憬の路	**7.2; 2.7**
2023-11-03〜05 2023-11-12	第７1回竹原市総合文化祭	0.3; 0.5; **0.8**; 1.0

Date	Event	Deviation
2024-01-01/02	元旦	1.0; **1.7**
2024-02-24 2024-03-03 2024-03-16	第18回たけはら町並み雛めぐり	**1.5**; 0.3; 0.3
2024-3-30/31	さくらライトアップ	0.8; 0.3
2024-04-06/07	パンプーお花見デー	**1.0; 2.4**
2024-04-13/14	忠海床祭り	0.5; 0.5
2024-04-28	プチ）デザインマンホール展	**1.5**
2024-05-03/04	竹祭り	**4.1; 3.4**
2024-06-01	忠海ゆかた祭	0.3
2024-06-29	つなぐ！第4回わんぱく相撲	**1.5**
2024-07-06	七夕祭り	**1.0**
2024-07-13〜2024-08-13	大久野島海水浴場	0.8; 0.3; 0.3; **2.2**
2024-07-14	忠海祇園祭	0
2024-07-20/21	住吉祭り	0.5; 0.5
2024-07-27	忠海天神夜市	0.8
2024-08-24	竹原花火大会	**7.9**
2024-9-23	9/23（月・祝）地域共生社会の取組の一環として、誰もが楽しむことができる「バリアフリー演劇」	**1.2**
2024-9-28/29	しまなみ映画祭２０２４	0
2024-10-13	2024年秋のグリーンアップ大作戦	**1.7**
2024-10-20	一緒にラグビーやり	**1.0**
2024-10-26/27	憧憬の路；smile park	**4.3, 1.9**
2024-11-03	第７２回竹原市総合文化祭	**1.9**

Table 3: List of Events in Takehara City Matched with Identified Days

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