Analyzing GASTech Building Operations Data

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*Abstract*— We examined GAStech's operational data in the 2016 VAST Challenge to interpret worker movements and building conditions. Our primary goal was to identify various anomalies and to make sense of the complexity, we created several visualizations. Through comparisons and visual cues, users could identify anomalies in the employee movements and environmental data displayed in these visualizations. It did more than watch; it actively sought out and linked anomalies. Examples from real life demonstrate how effectively it transforms data into interesting narratives. This research advances the field of visual analytics by offering a stable and intuitive framework for figuring out complicated operational data, as demonstrated by GAStech's challenges in the 2016 VAST Challenge.

Keywords—Visual Analytics, Anomaly detection, Visualization.

# Introduction

Our research project is centered around a detailed exploration and analysis of the GASTech Building Operations datasets, specifically from the VAST Challenge 2016, with a focus on Mini-Challenge 2 [1]. This challenge is set within the context of the GAStech headquarters, a state-of-the-art three-story building situated on Kronos Island. The data for this project was meticulously generated using the U.S. Department of Energy's Energy Plus building simulation software [2], creating a realistic and comprehensive model of the GAStech headquarters. This model encompasses detailed floor plans, energy zones, and general building schedules for utilities like electricity, heating, lighting, as well as occupancy patterns.

A unique aspect of this challenge is the incorporation of a simulated insider threat scenario, featuring suspicious employee movements and prox card manipulations, which were designed to cause anomalies in building energy usage [3]. The simulation also included environmental factors such as CO2 levels and a fictional hazardous gas, Hazium, to add complexity to the building's operational data.

The data sets provided include detailed prox card data from employees, sensor readings from various HVAC zones, and additional data from an innovative mobile sensor, Rosie the Robot. Rosie serves as a mail-delivering robot equipped with a prox card reader, adding a layer of mobile sensing to the data.

Our analysis aims to dissect and understand the intricate interplay between employee movements, building operations, and the injected insider threat elements. By employing sophisticated data visualization tools and analytical techniques, we plan to extract valuable insights and detect patterns that could indicate potential security breaches or inefficiencies in the building operations. This comprehensive approach will not only help in identifying anomalies and threats but also contribute to enhancing the overall efficiency and security protocols of the GAStech Corporation’s facility [4, 5]. The ultimate goal is to produce findings that are not only insightful in understanding the current datasets but also instrumental in formulating strategies for similar real-world scenarios.

# Problem Statement

The new GAStech building designed for energy efficiency, is equipped with HVAC zones monitored by sensors reporting various parameters, including hazium levels. Additionally, new security procedures involving prox cards have been implemented, and a robotic mail delivery system named Rosie with a mobile prox sensor operates within the building to analyze two weeks of static data (May 31 to June 13, 2016).

# Goals and Objectives

Our goals as researchers cover a broad investigation of GAStech's operational data. We aim to provide prox card data visual analysis of common patterns to provide insights into employee movements. Furthermore, we aim to create a visual narrative that captures the essence of an average GAStech employee's day, revealing the intricate details of their everyday activities. To shed light on the operational dynamics of the company, we also concentrate on obtaining significant insights from larger building data patterns. We aim to improve our comprehension of environmental conditions by estimating correlations within sensor readings through careful investigation. Our research is always looking for anomalies and tries to pinpoint any odd activity in employee activities and sensor readings. Our ultimate goal is to clarify the causal connections between building data and employee behavior, which will help us fully comprehend the intricate workings of GAStech..

# Analysis

Our comprehensive analysis of the GASTech building's operational data has provided us with detailed insights into the workday routines and shift patterns of the employees. Generally, employees adhere to a standard work schedule, arriving at 8 am and departing at 5 pm on weekdays, with weekends typically quiet. However, we observed diversity in shift timings, with some employees, particularly in facilities and IT, working from 4 pm to midnight and from midnight to 8 am. This is exemplified by individuals like Virgil Hatchett and Luis Bagani, who, despite working different shifts, both frequently visit the deli during their respective lunchtimes—a common practice among most employees, especially from the Engineering, Facilities, and IT departments.

Unique patterns were found when the building's prox card data was further examined. The highlighted points on our plots show that Yuko Finney, Walton Reynoso, and Marin Onda frequently leave their proximity cards in their offices. On the other hand, we believe that Nicoloi Cello and Raphale Faraldo displayed anomalies in their check-in locations because the mobile robot scans registered in adjacent zones that overlapped.

A particularly striking observation is the significantly higher energy consumption on the third floor compared to other floors, which persists even during weekends. This anomaly could be attributed to construction equipment on the third floor that requires substantial energy or possibly to an area being repurposed for high-energy-demand activities. Additionally, thermostat temperature readings across all energy zones on June 7th and 8th were higher than typical for this time of year, suggesting deviations in climate control settings or system inefficiencies. These findings not only provide a snapshot of employee patterns but also raise questions about energy usage and efficiency within the GASTech headquarters. A graph of a graph

Description automatically generated with medium confidence Fig.1 Combined Time Series of Hazium Concentration

From the Fig. 1 we can see that, the Hazium gas readings from the GASTech facility show pronounced spikes, especially on the third floor and across all floors on Saturday 11th, indicating potential hazards that could be linked to incidents, with the elevated levels on the third floor possibly resulting from construction activities.

A graph of different colored lines

Description automatically generated Fig.2 Time Series of CO2 Concentration

Throughout the dataset, the CO2 sensor readings as we can see in Fig. 2, adjusted by approximately ±10 standard deviations from the mean and color-coded by floor, indicate that Floor 2 consistently exhibited the highest carbon dioxide concentrations, with particularly sharp peaks on Wednesday, June 7th, and Thursday, June 8th, which likely corresponds with a significant event detected by most sensors on these days.

# Results

Our analysis of the GASTech building operations has uncovered several anomalies that warrant further investigation. Firstly, there were two unusual prox card activities during the weekend; Mat Bramar and Orhan Strum's cards were used at times that coincide with each other and just before a weekend Hazium gas outbreak, suggesting a possible link. Secondly, the boiler’s water temperature sensor data appears counterintuitive, showing higher temperatures at night despite higher solar energy during the day, which may indicate a sensor calibration issue given its daily repetition.

Additionally, a notable absence of employees in the server room on June 9th aligns with high CO2 levels from previous days, hinting at environmental conditions affecting employee attendance. The Executive group also displayed atypical behavior, spending less time in the office on June 8th, while the Facilities group worked overtime on June 7th, likely addressing the temperature issue. Geneviere Florez's frequent card reissues and a suspicious midnight entry point to security lapses, underscoring the need for improved security protocols. Moreover, CEO Sten Sanjorge Jr’s card recorded an entry around midnight on June 1st/2nd, an outlier to his regular working hours, adding another layer of anomaly to the findings. These patterns raise concerns about potential unauthorized access and operational irregularities, suggesting that certain employees may be exploiting vulnerabilities in building operations and security.

# Future Eork

Leveraging machine learning to optimize HVAC systems presents a forward-thinking approach to balancing energy efficiency with employee comfort. By tailoring climate control based on predictive analytics, we can create adaptive environments that preemptively adjust to the needs of the occupants. Concurrently, expanding our sensor network to include hazium detectors enhances our environmental monitoring, safeguarding against air quality hazards. Employing association rule mining allows us to decipher complex relationships between various sensor outputs, enabling us to predict and respond to environmental changes with precision, ensuring a safe, comfortable, and energy-efficient workplace.

# Conclusion

Our analysis of GASTech's operations has identified several anomalies that suggest security and operational issues. Unusual access card usage linked to a Hazium gas outbreak, anomalous boiler temperatures, and inconsistencies in employee presence correlating with environmental conditions indicate potential vulnerabilities. The peculiar behavior of the Executive group, extra hours logged by the Facilities group, frequent card reissues for one employee, and the CEO's entry during off-hours all point to a pattern of irregularities. These findings highlight the urgent need for a review and strengthening of security measures and operational protocols to address these potential risks.

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