Sutardja Dai Hall Sensor Data Visualization

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Abstract

This research project aims to explore the potential of building sensor data to improve the understanding of a building's overall workings. Specifically, the project focuses on collecting and analyzing sensor data from Sutardja Dai Hall, an important part of the UC Berkeley campus. By developing an interactive dashboard that deploys visualizations using plan drawings of the building, the project seeks to simplify the analysis of the sensor data and make it easier to understand its spatial location analyses within the building. The dashboard will have a range of use cases, including integrating with BIM modelling, understanding energy and utility needs, and predicting future failures in building maintenance services. Through this project, we hope to showcase the power of building sensor data and its potential to transform the management and maintenance of buildings.

1. Introduction

The Sutardja Dai Hall (SDH) at UC Berkeley is a smart building that includes 255 sensor time series from 51 rooms in 4 floors. The dataset provides measurements of CO2 concentration, room air humidity, room temperature, luminosity, and PIR motion sensor data, collected over a period of one week from August 23 to Aug 31 in the year 2013. Previous work in building sensor data is used to predict building operational failures, reduction in energy plug loads, occupancy prediction within each space of a building and many design and operational use cases for the data. But the research with sensor data is very limited and inclined towards data scientists and machine learning engineers. There is no research or real time dashboard of a building particularly used for data tracking and analysis that can be a easy read for stakeholders and data storytelling in a building. The objective of this project is to build an interactive data visualization dashboard using the SDH sensor dataset. The dashboard will display the sensor data from the 51 rooms in the building, including CO2 concentration, room air humidity, room temperature, luminosity, and PIR motion sensor data, collected over a period of one week. The dashboard will leverage plan drawings of the building to make it easier to understand the spatial location of the sensor data within each room. The project aims to simplify the analysis of the sensor data and make it more accessible to building management professionals. The results of this research will have practical applications in building management and energy optimization, and could serve as a basis for similar projects in other smart buildings.

Figure 1. Sutardja Dai hall

2. Design and Implementation

Design and implementation plan for building a data visualization dashboard using the Sutardja Dai Hall(SDH)dataset involved the following steps to cleaning and preprocessing data to the final dashboard. For understanding purpose I am only considering the 4th floor data.

1. Data Collection content: The sensor data for SDH is available online on the following link (Kaggle link). Each room includes 5 types of measurements: CO2 concentration, room air humidity, room temperature, luminosity, and PIR motion sensor data, collected over a period of one week from Friday, August 23, 2013 to Saturday, August 31, 2013. The PIR motion sensor is sampled once every 10 seconds and the remaining sensors are sampled once every 5 seconds. Each file contains the timestamps (in Unix Epoch Time) and actual readings from the sensor.

The passive infrared sensor (PIR sensor) is an electronic sensor that measures infrared (IR) light radiating from ob-

	date	hour	room	co2	humidity	light	pir	temperature
0	2013-08-24	0	413	527.41	44.40	133.43	0.00	24.59
1	2013-08-24	0	415	539.77	51.52	75.10	0.00	23.59
2	2013-08-24	0	417	408.33	51.29	58.86	0.00	23.73
3	2013-08-24	0	419	557.42	52.26	145.33	16.83	73.18
4	2013-08-24	0	421	400.58	52.86	187.18	0.00	23.13

Figure 2. First 5 rows of the cleaned dataset

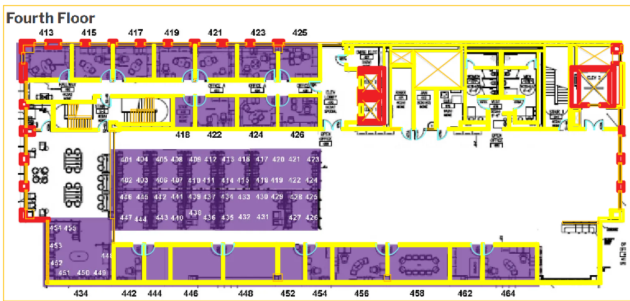

Figure 3. Autocad raster drawing

jects in its field of view, which measures the occupancy in a room. Approximately 6 percent of the PIR data is non-zero, indicating an occupied status of the room. The remaining 94 percent of the PIR data is zero, indicating an empty room.

The data is divided room wise wherein the each folder has a room name within which there are .csv files for the measures.

2.. Data Cleaning and Preprocessing:

For Data cleaning the Python was used to extract the csv files from the folders, put into 1 dataset. As the epoch time stamps were in seconds, the timestamp column was converted to Datetime to standardize the datetime. The dataset was further grouped by date, hour and room to get mean values of each column per hour per day for each room. The dataset was further filtered with values between Aug 23 to Aug 31. The final dataset contains 2688 rows and 8 columns.

Complete data cleaning documentation at : (Github link)

3. Plan drawing documentation :

The actual 4th Floor plan of the Buildings were extracted from the following website: (Floor plans link)

The image for the 4th floor plan was exported to an architectural drafting software - Autocad that helped raster the plan images and scale it to reproduce cleaned floor plans for the dashboard. 4. Extracting rectangle shape data for the rooms :

The floor plan rastered on the Autocad drawing is again exported as an image to upload onto a website where we can get location co ordinates of the point for that image. The dataset for points is automatically stored and can be extracted after every room point is placed and given a shape

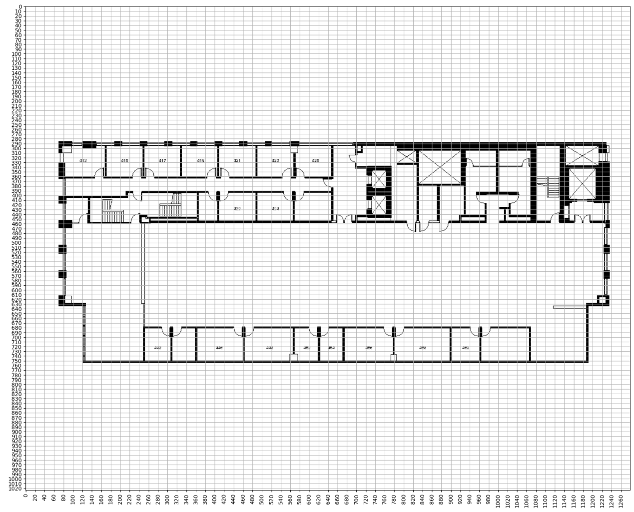

Figure 4. Floor plan image with X and Y co-ordinates

shapeId	shapeType	shapeLabel	pointId	pointX	pointY
0	polygon	413	0	78	729
0	polygon	413	1	170	730
0	polygon	413	2	171	665
0	polygon	413	3	76	665
1	polygon	415	0	252	731
1	polygon	415	1	170	730
1	polygon	415	2	171	665
1	polygon	415	3	249	662
2	polygon	417	0	330	732
2	polygon	417	1	329	660
2	polygon	417	2	249	662
2	polygon	417	3	252	731
3	polygon	419	0	407	732
3	polygon	419	1	410	658
3	polygon	419	2	329	660
3	polygon	419	3	330	732

Figure 5. Data extracted from the shape points website

label of the room number.

The website used for this task is : (Website link)

5. Dashboard Development:

Both the datasets are imported to Tableau, namely the original cleaned dataset of all sensor values and the shapes data set. The datasets are connected on Tableau with connection on the room number column and shape label column.

We consider to make 3 different worksheets for each column that is filtered on Date and Hour. We import the background image for the plan visualization heatmap on tableau. We add the X and Y columns in the shape file as X and Y co ordinates for the graph and change the 'Marks ' graph to rectangle.

Once the shapes are plotted we can assign each Column

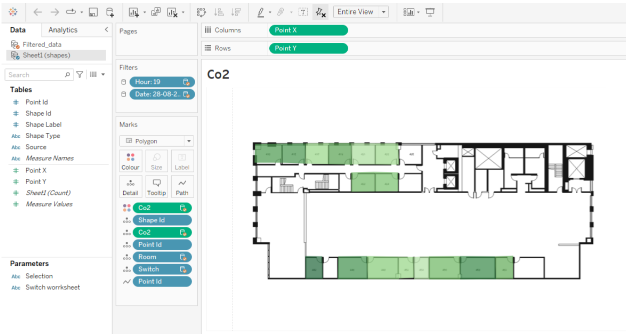

Figure 6. Tableau process

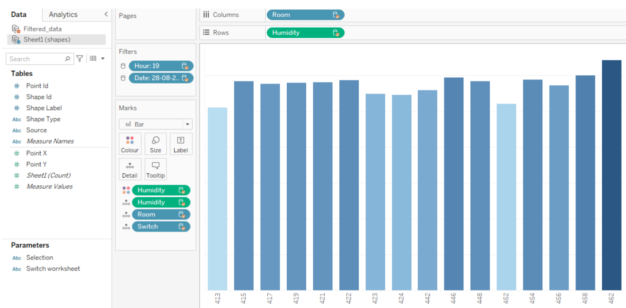

Figure 7. Bar graph-Humidity

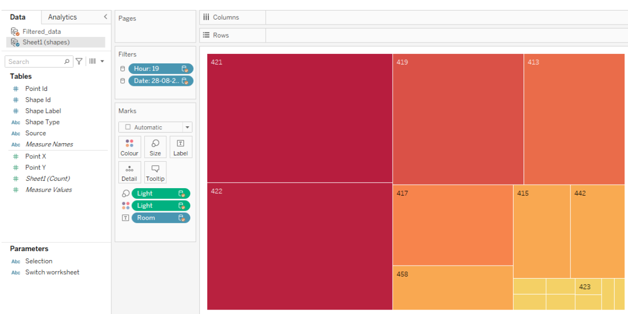

Figure 8. Rank graph-Light

of CO_2, Humidity, Light, temperature and Pir to the shapes of rooms on different worksheets. The bar graphs and Rank charts are developed without the plan for each value of the column in the dataset. With filters of Date and Hour added for each worksheet, the worksheets are ready to be added to the dashboard.

3. Future research

One potential avenue for future research in this area is to investigate the effectiveness of incorporating machine learning algorithms in analyzing the sensor data from buildings. By leveraging machine learning techniques such as clustering, regression, and anomaly detection, it may be possible to identify patterns and anomalies in the data that are not immediately apparent through visualizations alone. Additionally, further exploration could be done on the integration of building sensor data with other sources of information, such as weather data or occupancy data, to gain a more holistic understanding of a building's operations and needs. Such research could ultimately lead to more efficient and effective management and maintenance of buildings, resulting in cost savings and improved sustainability.

Another potential direction for future research is the integration of 3D models of buildings into the interactive dashboard for sensor data analysis. By overlaying sensor data onto a 3D model, it may be possible to gain a more intuitive understanding of the data and identify issues that may not be immediately apparent through 2D visualizations. Furthermore, the use of virtual and augmented reality technologies could enable users to explore the building and its sensor data in an immersive and interactive way.

References

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[3] CITRIS. Sutardja dai hall demand response. Retrieved April 10, 2023, from https://citris-uc.org/research/project/sutardja-dai-hall-demand-response/, 2022. 2

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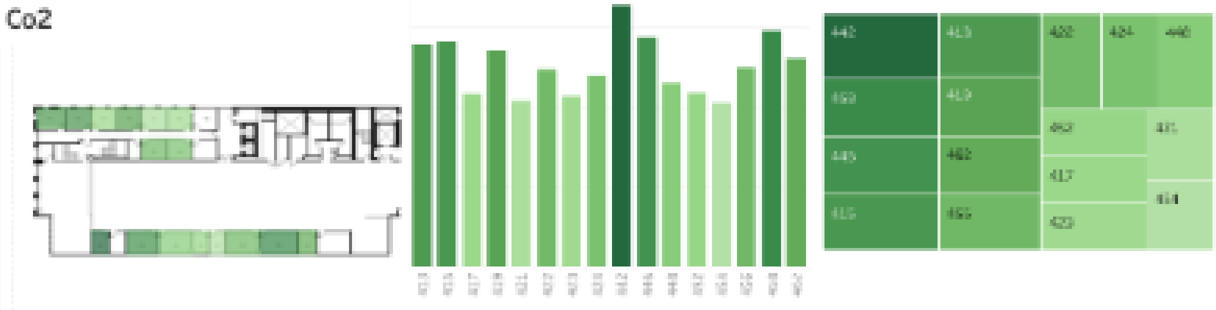
[5] Peng Zhao, Therese Peffer, Ram Narayanamurthy, and et al. Getting into the zone: How the internet of things can improve energy efficiency and demand response in a commercial building. *Indoor Environmental Quality (IEQ)*, 2016. 2

Sutardja Dai 4th Floor Sensor Data

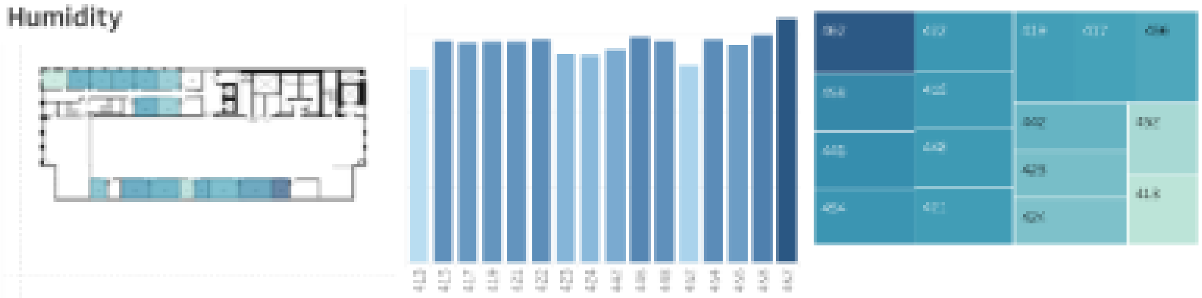
Date

Hour

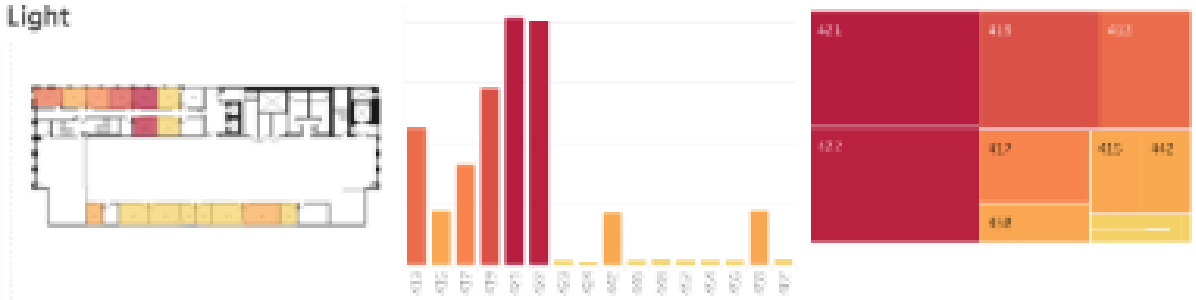
Co2



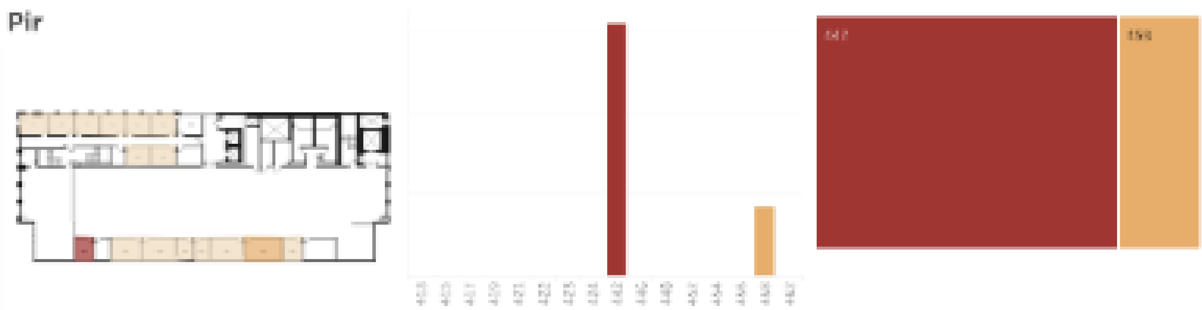
Humidity



Light



Pir



Temperature