CS 5304 Final Report: Boilers in NYC

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May 11, 2019

1 Introduction

Landlord/tenant relations is a hot-button topic in New York City. To understand some of the issues that tenants face, we explored datasets provided by the NYC Department of Buildings (DOB). Our goal is to characterize tenant issues, categorize the ways in which landlords respond, and ultimately define, or optimize, a process for approaching and solving these issues. We decided to follow a model designed by the Mayor's Office of Data Analytics (MODA).In their work, MODA developed a model to prioritize inspections of buildings that had complaints regarding illegal conversions. The purpose of the MODA project is to use DOB inspection and violation data to perform an analysis of historical outcomes, find common traits of illegal apartments that are vacated, and use that data to risk-analyse new complaints to prioritise future inspections. [1]. Similarly, we have developed a model which scores and prioritizes boiler complaints based on the likelihood of a complaint leading to a violation. With this model, the Department of Buildings' Boiler Unit can schedule inspections based on the severity of complaints and the probability that they will encounter a boiler violation or serious problem upon inspection. In doing so, the model saves the city time and money, helps to identify potentially dangerous boiler issues based on boiler features and historical data, and prioritizes responses to tenants whose complaints are not being addressed by their landlords. We believe the lessons learned from this model can be used in future work to generalize to other landlord/tenant issues.

1.1 Background

Landlords are beholden to fix tenant issues quickly and completely. Unfortunately, not all landlords or management companies follow the same definition of "quickly". In New York City, if a tenant is experiencing a problem within their building, they are first directed to contact their landlord and file a complaint. If the landlord does not respond or resolve the issue in timely manner, the tenant is urged to file a complaint with the DOB by making an anonymous call to 311. One of the DOB's main tasks is to ensure properties are maintained and are in safe condition. Failure on the part of the landlord to do so can result in violations, fines, and/or criminal charges [2]. With a formal complaint lodged, the DOB will send inspectors to survey the property and potentially cite any violations found.

There is a wide swath of inspections that the DOB oversees. The two that interested us the most were boiler and elevator inspections. Apart from the utility they provide, both can be fatally dangerous if not properly maintained. In surveying the data (discussed below) we found data on boiler inspections, complaints, and violations to be more comprehensive and actionable. Most importantly, the DOB maintains and updates boiler records daily, as yearly inspections are required for the million-odd buildings under DOB jurisdiction [3].

1.2 The Data

We are using the "DOB Complaints Received" dataset from NYC OpenData to understand complaints received by the DOB [5]. The dataset was created on April 18, 2013, was updated as recently as May 9, 2019, and has 2.3 million rows and 15 columns. This dataset gives us insight into the type of complaints lodged with the DOB, which complaints resulted in violations, how quickly each complaint was addressed, and which complaints are directly related to boilers. Table [1] lists some of the more important columns:

Column Name	Description	Type
BIN	Number assigned by City Planning to a specific building	Plain Text
Date Entered	Date Complaint was Entered	Plain Text
Complaint Category	DOB Complaint Category Codes	Plain Text
Complaint Number	Complaint number starting with borough code	Plain Text
Disposition Code	Disposition Code of Complaint	Plain Text
Status	Status of Complaint	Plain Text

Table 1: Select Rows from the DOB Complaints Dataset

Next, we looked at the "DOB NOW: Safety Boiler" dataset from NYC OpenData to see the types of boilers installed throughout the city [6]. The dataset was created on September 14, 2017, was updated as recently as May 9, 2019, and has 171K rows and 21 columns. This dataset covers the annual compliance filings for high and low pressure boilers installed in buildings in NYC. Using the "BIN" field found in both datasets, we are able to join boilers with boiler complaints. Table [4] lists some of the most important columns:

Column Name	Description	Type
BIN	Number assigned by City Planning to a specific building	Plain Text
Boiler Make	The manufacturer of the boiler	Plain Text
Boiler Model	The model of the boiler	Plain Text
Pressure Type	The type of boiler: either low or high pressure	Plain Text
Inspection Type	Internal or External	Plain Text
Inspection Date	Date that the boiler was inspected	Plain Text
Defects Exist	True or False	Plain Text
Report Status	Expected Values: Pre-Filing, QA Review, Rejected, Accepted	Plain Text

Table 2: Select Rows from the DOB NOW: Safety Boiler Dataset

1.3 Visualizing the Data

Fig. 7 shows the DOB's resolution time for boiler complaints over the entire dataset. With this visualization, we can compare resolution time for complaints that *do* result in a violation, versus those that *do not*. In addition, we can compare resolution time, if a complaint warranted a violation, and the complaint type to better understand how the DOB prioritizes their inspections. We found that their prioritization framework allows them to address the most critical boiler complaint types first (Explosion - "82" and Fumes - "56"), however, they do not optimize for complaints of category B (Boiler Defective/Non-operative/No permit - "58"). Even with this distinction, we see that complaints which *do* result in a violation can still linger for weeks and sometimes even months unresolved.

Fig. 2 shows the DOB's resolution time for Priority B (Boiler Defective/Non-operative/No permit) boiler complaints. With this visualization, we see that the majority of Priority B complaints do not result in violations. Ideally, we would like this plot to look more separated; complaints that do result in violations (yellow)

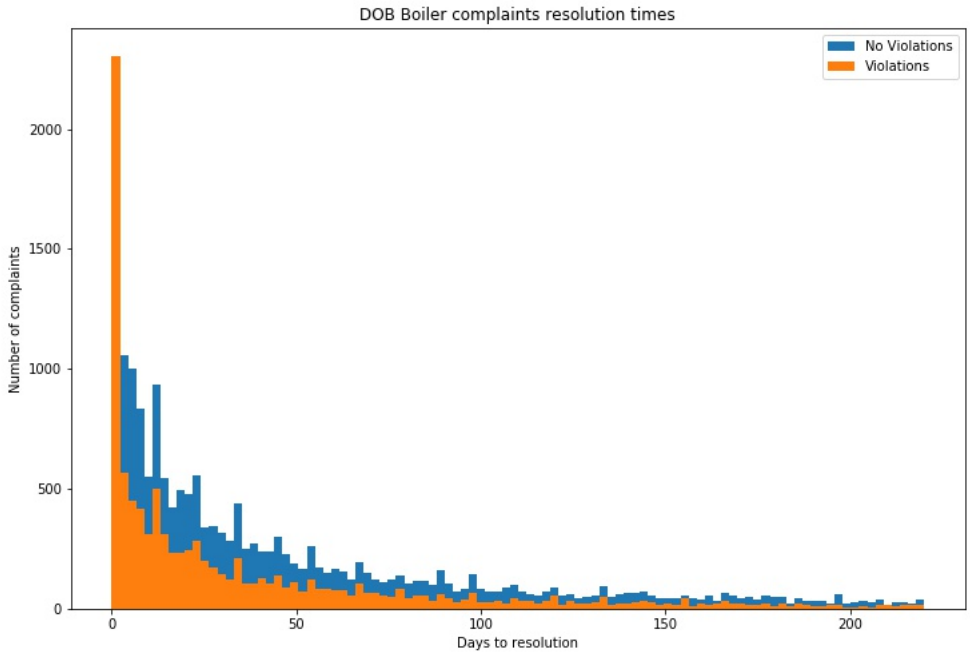

Figure 1: DOB Boiler Complaint Resolution Times

would be resolved sooner, while complaints that do not result in violations (blue) can take longer as they involve less risk and require less work.

Lastly, the DOB has 426 building inspectors on staff [8] to facilitate inspections for the roughly 1 million buildings in the city and their corresponding boilers, elevators, facades, and other facilities [9]. In recent years, there has been a push to increase the responsiveness of the agency through increased staffing and an updated website for scheduling inspections. As shown in Fig. 3, we still see that the number of complaints that do not result in violations are outnumbering those that do. Overall the response times are down, which is encouraging, but we believe we can help the DOB to work even more efficiently and address safety issues in a more timely manner by prioritizing higher risk complaints.

2 The Problem

According to SiteCompli [7]:

> "Time frames are not given for complaint-based inspections; complaints are typically investigated on the perceived severity of the issue. An inspector may not visit the site for some time, and as a result, the complaint will remain open in the DOB's records. Once an inspector arrives onsite to investigate a complaint, they may do one of two things: close the complaint for lack of an infraction, or close the complaint and issue a resulting DOB-ECB violation."

Inspectors are deployed to sites based on perceived complaint severity, resulting in some sites not being visited and complaints remaining pending. Worse, sites are visited but the inspectors are unable to access the property. In addition, we found that only 30% of boiler inspections result in a violation, and less than

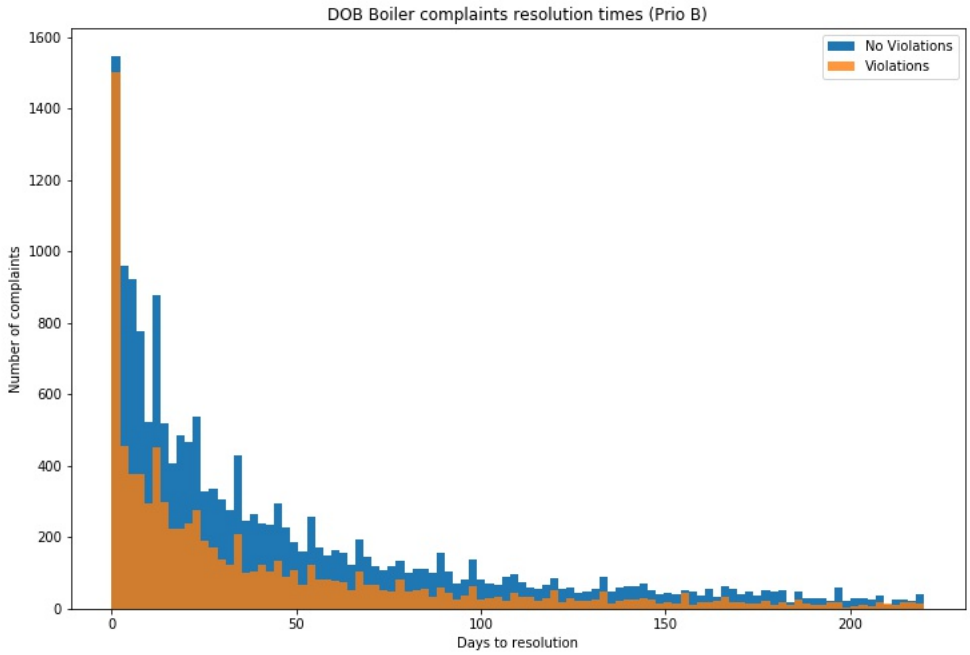

Figure 2: DOB Priority B Boiler Complaint Resolution Times

25% of boiler complaints are resolved within a week.

We are working to improve the complaint prioritization process. Severe complaints take precedent, but we can enrich this process by accounting for boiler features, and historically identifying which combination of boilers and complaints are most likely to result in a violation. The benefit of focusing on cases where violations are more likely is two-fold: 1) safety related cases are more likely to result in violations and will remain high priority, and 2) complaints which aren't addressed in a timely manner due to lack of resources are less likely to result in a violation. In other words, we can more accurately account for the fact that 70% of cases do not result in a violation and prioritize accordingly.

2.1 Assumptions

In solving this problem, we are operating under 3 major assumptions:

1. There are not enough resources to carry out boiler inspections in a timely fashion.
2. Boiler inspections not resulting in violations implies there were no defects found with the boiler.
3. The number of complaints a building receives speaks to the quality of the building/management.

3 Feature Selection and Preprocessing

To define our feature set and labels, we first filter down the "DOB Complaints Received" dataset by Complaint Category to obtain the boiler related complaints. Table 3 includes a summary of the totals for each

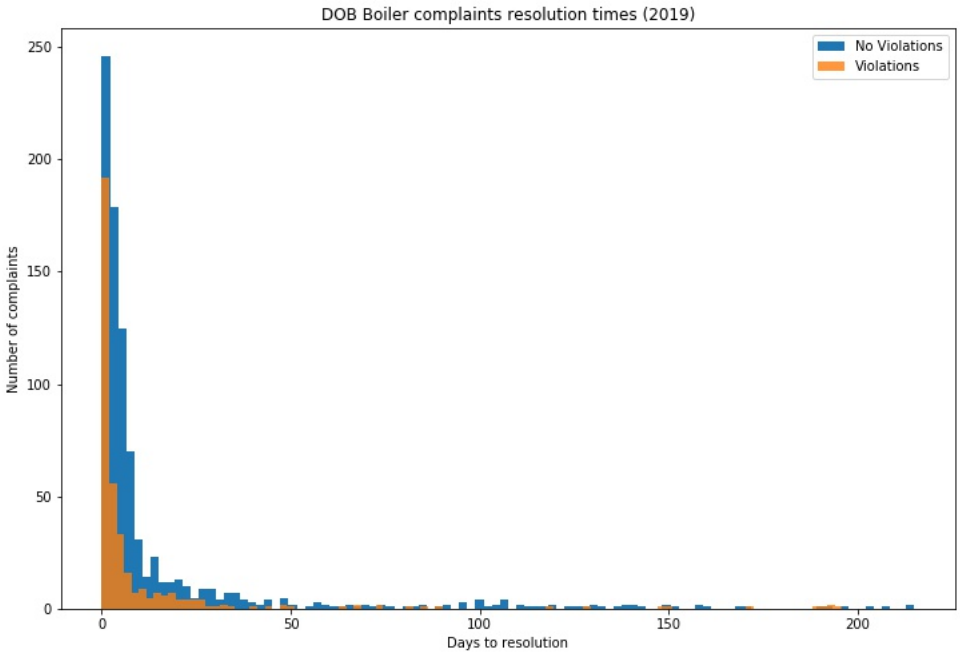

Figure 3: DOB Boiler Complaint Resolution Times for 2019

boiler complaint category. We are only considering complaint category code 58 as they are the most numerous complaint and are the type of complaint with the worst response time and violation to complaint ratio. [10]

Code	Complaint Category	Priority	Total
56	Boiler – Fumes/Smoke/Carbon Monoxide	A	2529
58	Boiler – Defective/Non-operative/No Permit	B	29745
82	Boiler – Accident/Explosion	A	36

Table 3: Number of Boiler Complaints by Complaint Category

3.1 Labels

Each DOB complaint has a "Disposition Code" which describes how the complaint was dealt with. Complaints can result in a variety of dispositions: building violation, inspector unable to gain access, no violation or referred to another agency. Figure 4 is a bar chart summarizing the disposition code breakdown of boiler complaints.

We are making this a binary classification problem by grouping disposition codes by codes that resulted in violations and codes that did not. A8 (ECB Violation Served), A1 (Buildings Violation(s) Served), B1 (Buildings Violation(s) Prepared and Attempt to Serve will be Made) account for a vast majority of the complaints that result in a violation. I2 (No Violation Warranted for Complaint at Time of Inspection), I1

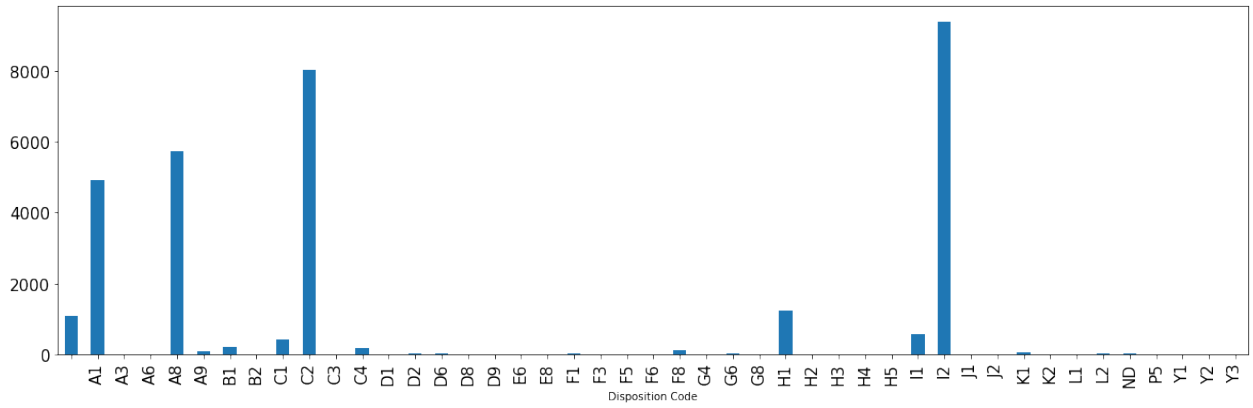

Figure 4: DOB Boiler Complaint Disposition Codes

(Complaint Unsubstantiated Based on Department Records) account for a vast majority of the complaints that do not result in a violation. It is important to note that we did not include C2 (Inspector Unable to Gain Access – Final Attempt) because we believe determining if a building is locked or not is a separate classification problem. Therefore, we are assuming inspectors can gain access to all buildings for our classification problem. The labels are balanced with 51% of the data points resulting in violations and 49% not resulting in violations

3.2 Features

Much of our time has been spent extracting and encoding relevant features. The six features we believe are useful in predicting violations are described in Table 4. All categorical features are ordinal encodings.

Feature	Dataset	Type	Total
Violation Ratio (# Previous Violations / # Previous Complaints)	DOB NOW: Boiler Safety	Continuous	N/A
ZIP Code	DOB NOW: Boiler Safety	Categorical	203
Boiler Make	DOB Boiler Inspections	Categorical	121
Number of Previous Violations	DOB NOW: Boiler Safety	Continuous	N/A
Number of Previous Complaints	DOB NOW: Boiler Safety	Continuous	N/A
Number of Previous Defects	DOB Boiler Inspections	Continuous	N/A

Table 4: Number of Boiler Complaints by Complaint Category

3.2.1 Data Cleaning

Linking the two datasets present numerous problems that require extensive data cleaning. Every complaint and inspection has a given building identification number (BIN). When joining the two datasets we found that only about 63% of complaints have a corresponding inspection in the DOB NOW dataset. In theory, every boiler in NYC is required to obtain a yearly inspection and all inspections must be recorded in the DOB NOW dataset. There could be a number of reasons why only 62% of complaints have a corresponding inspection. NYC BINs are notoriously unreliable, a significant portion of boilers have not been inspected since 2017 (the beginning of the DOB NOW dataset) or failure to document boiler inspections. We use the 62% of complaints that had boiler inspections because the DOB NOW dataset provides very useful features for predicting violations. Our total number of data points for training and testing is about 10000.

Boiler Make is an extremely messy yet useful feature. The raw data set has over 2000 different boiler makes, yet upon further inspections it is obvious there are actually fewer due to typos and inconsistencies in documentation. To remedy this problem, we group similar makes by calculating string similarity using difflib.SequenceMatcher. We empirically set a threshold of similarity to optimize for performance. We were able to reduce the number of makes from over 2000 to 121.

4 Model Selection

We use a Random Forest classifier with 1000 estimators and max depth of 7. Our training split contains 6538 data points and our test size is 4358 (60%, 40%).

5 Results

Our training accuracy is 68% and our testing accuracy is 63%. Figure 5 is our ROC curve. Figure 6 is a summary of our feature importance. Figure 7 is our confusion matrix.

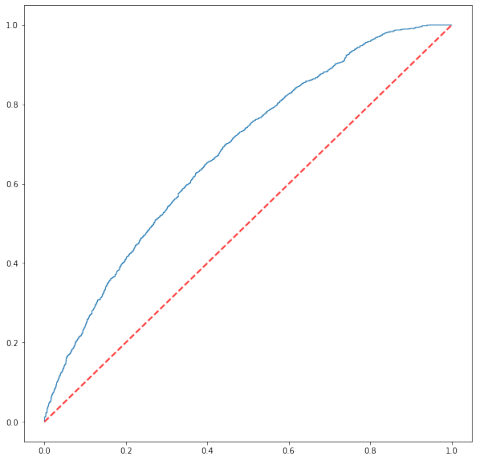

Figure 5: ROC Curve (Test Set)

While our testing accuracy is not amazing, we are able to perform noticeably better than random. Also, it is important to remember that inspectors handle complaints as they arrive via 311. Assuming order of complaints does not influence whether or not there is a violation, the inspectors are essentially randomly inspecting boilers. Therefor our model is a significant improvement on the existing method. Our model is producing confident classification which is what is important for allocating inspectors to complaints.

Our model has found that violation ratio, zip code and number of previous complaints are the most import features when determining whether a complaint will result in a violation. Zip code could be so informative because NYCHA buildings are notorious for having extremely poor maintenance. The importance of previous complaints affirms our assumption that the number of previous complaints is an indicator for future violations and the quality of building maintenance.

Our model does best at correctly predicting complaints that result in violations. However, we are producing a number of false positives.

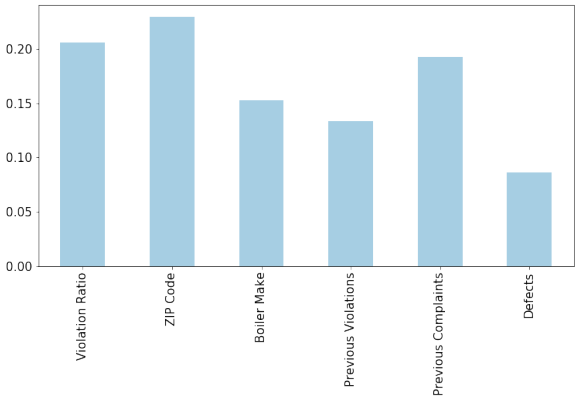

Figure 6: Model Feature Importances

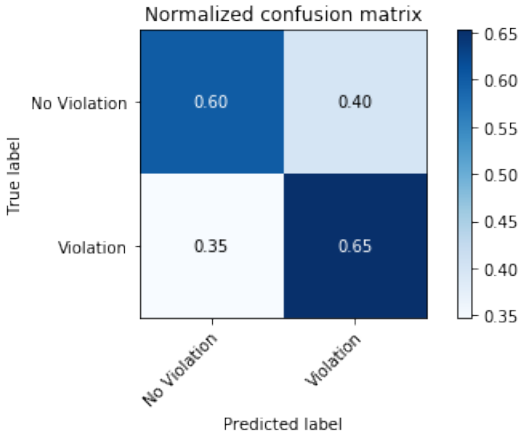

Figure 7: Model Confusion Matrix (Test Set)

6 Conclusion

We are able to produce an effective model that can prioritize boiler inspections given daily DOB complaints with just a handful of useful features. We found that zip code and number of previous complaints are important feature in classifying violations. Our feature selection and cleaning process revealed many limitations of NYC DOB datasets. We recommend the DOB standardize the documentation for boiler make and include boiler ID in the complaint dataset.

6.1 Next Steps

Our first step is to improve the accuracy of our model. We will do this by first gaining a better understanding of the DOB's process when determining priority for boiler inspections. Are they using a feature we are not? Based on our important features, location and building history data types are good predictors for violations. To increase the granularity of zip code, we could include the tax assessment of the building from NYC's PLUTO dataset. The tax assessment could encode location and building quality information. Instead of looking at just previous boiler complaints, we could include number of previous complaints other than boilers. Maybe buildings with other problems such as elevator malfunctions and illegal conversion complaints could indicate boiler violations.

Once we improve our accuracy, we would propose this model to MODA and DOB to test. We would implement a pilot similar to MODA: email the DOB inspectors of one borough each day with the highest priority complaints. After a month, we would then compare the effectiveness of the boiler unit in our pilot borough to all other boroughs.

References

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[10] https://www1.nyc.gov/assets/buildings/pdf/complaint_category.pdf