Using Text Analytics Solutions with Small to Medium Sized Manufacturers: Lessons Learned

Michael Brundage, National Institute of Standards and Technology

Radu Pavel, TechSolve Inc.

TechSolve®

NIST National Institute of Standards and Technology U.S. Department of Commerce

Outline

- Background on Maintenance Work Order Annotation
- Assessing Small to Medium Manufacturers
- Tagging Experiment
- Potential Analysis
- Future Work

Maintenance Work-order Data

"Hyd leak at saw atachment"

"HP coolant pressure at 75 psi"

"Major hydraulic leak at Sp#6 horseshoe"

"Replaced seal in saw attachment but still leaking – Reapirs pending with ML"

"Clamping spool guard broken"

"Bad Gauge / Low pressure lines cleaned ou"

"Replaced – Operator could have done this!"

"Repaired horseshoe seals"

Background

Traditional NLP techniques to **structure** this data require either :

- Well-formatted **grammar** and common **verbage**, OR
- A large enough **annotated** training set for ML

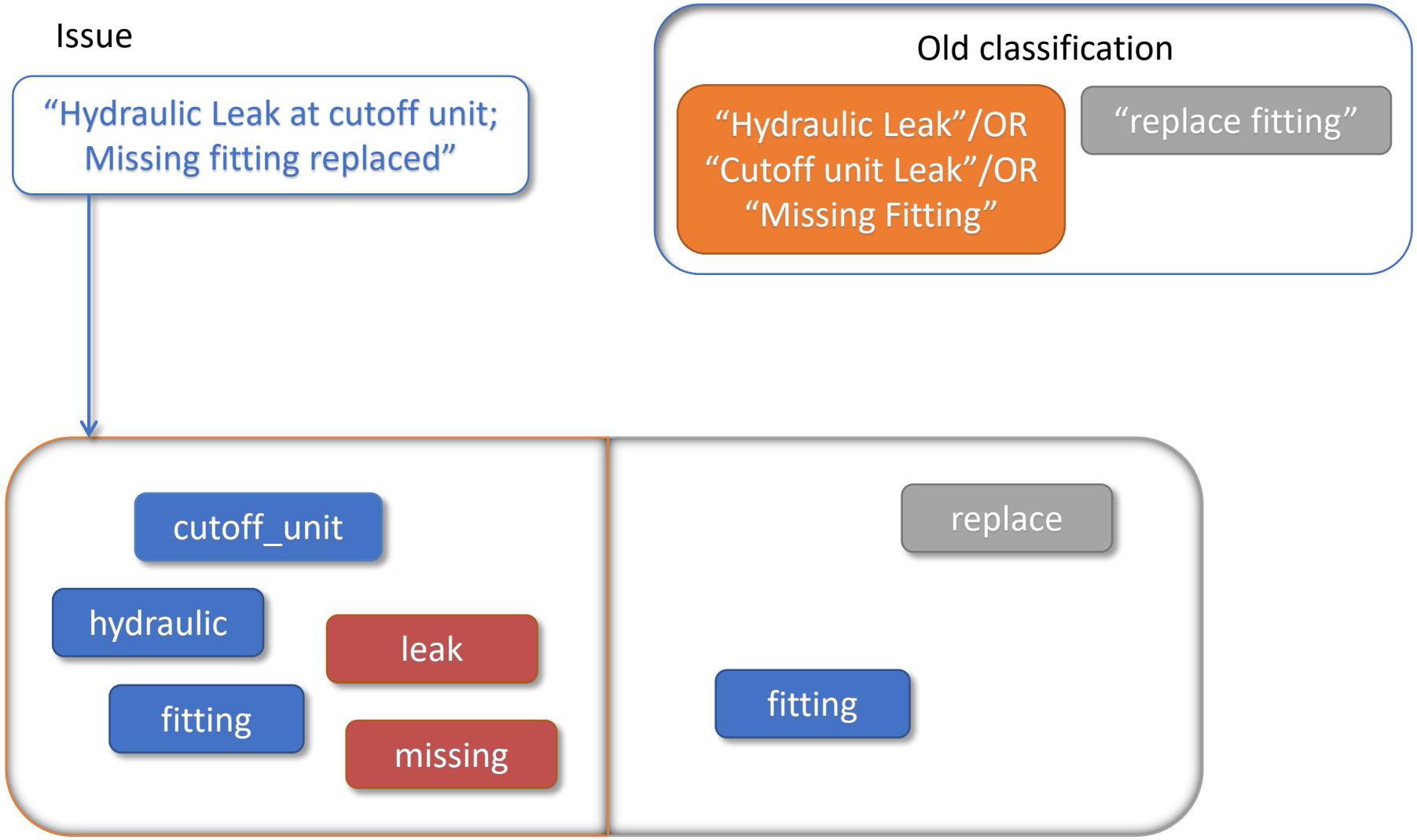
The value of our expert-generated data is in how specific the domain is

→ pre-training/transfer learning is *hard*

Datasets (1k – 100k) are too large to hand-annotate, and too small to learn high-quality embeddings

→ Need efficient, less-intensive annotations!

Using Tags for Efficient, Scalable Annotation



Ranked Tagging

Description	Resolution
“Hyd leak at saw atachment”	“Replaced seal in saw attachment but still leaking – Reapirs pending with ML”
“HP coolant pressure at 75 psi”	“Bad Gauge / Low pressure lines cleaned ou”
“Major hydraulic leak at Sp#6 horseshoe”	“Repaired horseshoe seals”
“Clamping spool guard broken”	“Replaced – Operator could have done this!”

Ranked Tagging

Description	Resolution
"Hyd leak at saw atachment"	"Replaced seal in saw attachment but still leaking – Reapirs pending with ML"
"HP coolant pressure at 75 psi"	"Bad Gauge / Low pressure lines cleaned ou"
"Major hydraulic leak at Sp#6 horseshoe"	"Repaired horseshoe seals"
"Clamping spool guard broken"	"Replaced – Operator could have done this!"

token	type	alias
repaired		
replaced		
leak		
seal		
hydraulic		
bad		
gauge		
low pressure		
reapirs		
hyd		

More Important

Ranked Tagging

Description	Resolution
"Hyd leak at saw atachment"	"Replaced seal in saw attachment but still leaking – Reapirs pending with ML"
"HP coolant pressure at 75 psi"	"Bad Gauge / Low pressure lines cleaned ou"
"Major hydraulic leak at Sp#6 horseshoe"	"Repaired horseshoe seals"
"Clamping spool guard broken"	"Replaced – Operator could have done this!"

token	type	alias
repaired		
replaced		
leak		
seal		
hydraulic		
bad		
gauge		
low pressure		
reapirs		
hyd		

Similar Words	Same as Repaired ? (Y/N)
Reapirs	
Repair	
Repir	
Rep	
Reparis	
Repaird	

Ranked Tagging

Description	Resolution
"Hyd leak at saw atachment"	"Replaced seal in saw attachment but still leaking – Reapirs pending with ML"
"HP coolant pressure at 75 psi"	"Bad Gauge / Low pressure lines cleaned ou"
"Major hydraulic leak at Sp#6 horseshoe"	"Repaired horseshoe seals"
"Clamping spool guard broken"	"Replaced – Operator could have done this!"

token	type	alias
repaired		
replaced		
leak		
seal		
hydraulic		
bad		
gauge		
low pressure		
reapirs		
hyd		

Similar Words	Same as Repaired ? (Y/N)
Reapirs	Y
Repair	Y
Repir	Y
Rep	N
Reparis	Y
Repaird	Y

Ranked Tagging

Description	Resolution
"Hyd leak at saw atachment"	"Replaced seal in saw attachment but still leaking – Reapirs pending with ML"
"HP coolant pressure at 75 psi"	"Bad Gauge / Low pressure lines cleaned ou"
"Major hydraulic leak at Sp#6 horseshoe"	"Repaired horseshoe seals"
"Clamping spool guard broken"	"Replaced – Operator could have done this!"

token	type	alias
repaired	S	repaired
replaced		
leak		
seal		
hydraulic		
bad		
gauge		
low pressure		
reapirs	S	repaired
hyd		

Similar Words	Same as Repaired ? (Y/N)
Reapirs	Y
Repair	Y
Repir	Y
Rep	N
Reparis	Y
Repaird	Y

Ranked Tagging

Description	Resolution
“Hyd leak at saw atachment”	“Replaced seal in saw attachment but still leaking – Reapirs pending with ML”
“HP coolant pressure at 75 psi”	“Bad Gauge / Low pressure lines cleaned ou”
“Major hydraulic leak at Sp#6 horseshoe”	“Repaired horseshoe seals”
“Clamping spool guard broken”	“Replaced – Operator could have done this!”

token	type	alias
repaired	S	repaired
replaced	S	
leak	P	
seal	I	
hydraulic	I	
bad	P	broken
gauge	I	
low pressure	P	
reapirs	I	repaired
hyd	I	hydraulic

Ranked Tagging

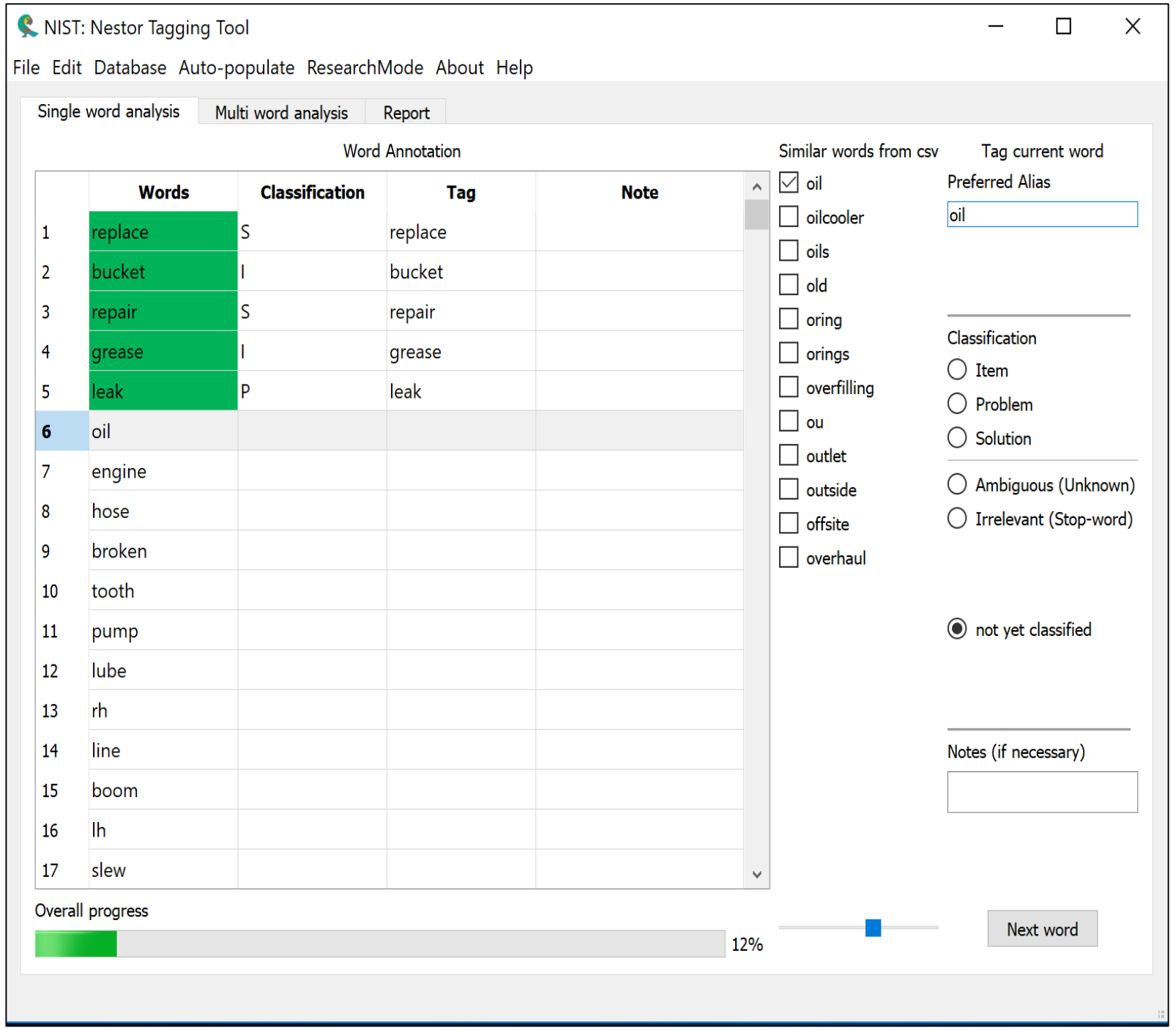
Description	Resolution	Item(s)	Problem(s)	Solution(s)
"Hyd leak at saw atachment"	"Replaced seal in saw attachment but still leaking – Reapirs pending with ML"	Hydraulic		
"HP coolant pressure at 75 psi"	"Bad Gauge / Low pressure lines cleaned ou"			
"Major hydraulic leak at Sp#6 horseshoe"	"Repaired horseshoe seals"	Hydraulic		
"Clamping spool guard broken"	"Replaced – Operator could have done this!"			

Ranked Tagging

Description	Resolution	Item(s)	Problem(s)	Solution(s)
"Hyd leak at saw atachment"	"Replaced seal in saw attachment but still leaking – Reapirs pending with ML"	Hydraulic		Replaced
"HP coolant pressure at 75 psi"	"Bad Gauge / Low pressure lines cleaned ou"			
"Major hydraulic leak at Sp#6 horseshoe"	"Repaired horseshoe seals"	Hydraulic		
"Clamping spool guard broken"	"Replaced – Operator could have done this!"			Replaced

Ranked Tagging

Description	Resolution	Item(s)	Problem(s)	Solution(s)
"Hyd leak at saw atachment"	"Replaced seal in saw attachment but still leaking – Reapirs pending with ML"	Hydraulic; Saw attachment; Seal	Leak	Replaced; Repaired
"HP coolant pressure at 75 psi"	"Bad Gauge / Low pressure lines cleaned ou"	High Pressure Coolant; Gauge; Low Pressure Line	Broken; Low Pressure	Cleaned
"Major hydraulic leak at Sp#6 horseshoe"	"Repaired horseshoe seals"	Hydraulic; SP#6 Horseshoe, Seal	Leak	Repaired
"Clamping spool guard broken"	"Replaced – Operator could have done this!"	Clamping Spool Guard; Operator	Broken	Replaced


NIST: Nestor Tagging Tool
File Edit Database Auto-populate ResearchMode About Help
Single word analysis
Multi word analysis
Report
Word Annotation
Words
Classification
Tag
Note
1 replace S replace
2 bucket I bucket
3 repair S repair
4 grease I grease
5 leak P leak
6 oil
7 engine
8 hose
9 broken
10 tooth
11 pump
12 lube
13 rh
14 line
15 boom
16 lh
17 slew
Overall progress
12%
Similar words from csv
oil
oilcooler
oils
old
oring
orings
overfilling
ou
outlet
outside
offsite
overhaul
Tag current word
Preferred Alias
oil
Classification
Item
Problem
Solution
Ambiguous (Unknown)
Irrelevant (Stop-word)
not yet classified
Notes (if necessary)
Next word

Outline

- Background on Maintenance Work Order Annotation
- Assessing Small to Medium Manufacturers
- Tagging Experiment
- Potential Analysis
- Future Work

Description of Company Assessment

- Conduct an assessment of the capabilities of text analytics technology developed by NIST, using maintenance data from manufacturing organizations.

- Contact small and medium size organizations to determine their practices relative to logging maintenance work orders

Sample Companies

No	NAICS Code	Employees	Annual Sales
Company 1	332119 - Metal Crown, Closure, and Other Metal Stamping (except Automotive)	50	$19M
Company 2	336350 - Motor Vehicle Transmission and Power Train Parts Mfg	200	$37M
Company 3	333514 - Special Die and Tool, Die Set, Jig, and Fixture Mfg	50	$10M
Company 4	442299 - All Other Home Furnishings Stores	10	$1.5M
Company 5	334413 - Semiconductor and Related Device Mfg	150	$48M

Points of Discussion

- What could improve your day-to-day maintenance tasks?
- How would you want to improve your maintenance long term?
- Why do you capture maintenance work order (MWO) data?
- Do you use this MWO data in your current maintenance analysis?
- What data do you use to determine your maintenance strategy?

MWO Collection Patterns

- Description of what was done
- Time to repair
- Date
- Who did repairs
- Why did repair need to take place

- Priority
- Code
- Assets
- Location Name
- Description
- Type
- Status
- Date Created
- Date Completed
- Completed By Users
- Requested by
- Time Est Hours
- Time Spent Hours
- Completion Notes
- … (17 headers)

- WorkOrderId
- WorkOrderNo
- Name
- ParentWorkOrderId
- ParentWorkOrderNo
- WOStatusId
- WOStatusNo
- WOStatusName
- PriorityId
- PriorityNo
- PriorityName
- WorkCategoryId
- WorkCategoryNo
- WorkCategoryName
- Etc. (over 400 headers)

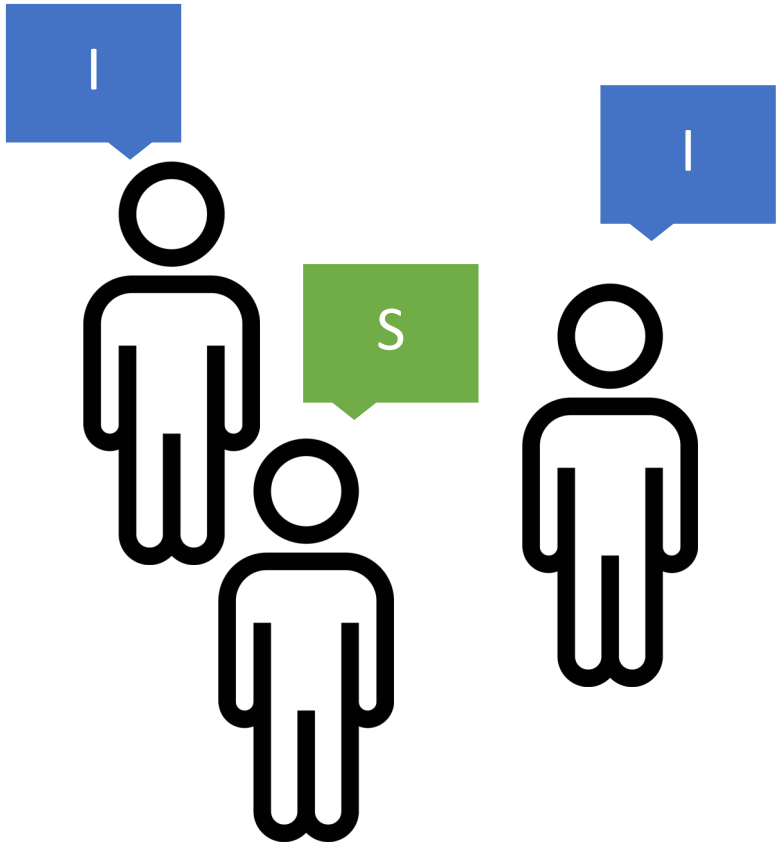
Observations

- The companies compliant with ISO 9001 and AS9100 are more likely to have maintenance work order data
- The companies that have maintenance records typically use a maintenance management system and the work orders are logged into a database
- All companies expressed the desire to get better analytics and ways of visualizing data that would allow them to better understand the maintenance activities and extract actionable information

Outline

- Background on Maintenance Work Order Annotation
- Assessing Small to Medium Manufacturers
- Tagging Experiment
- Potential Analysis
- Future Work

Tagging Exercise



“sealant”	type?	alias?	related?
Judge 1	I	**seal**	
Judge 2	I	**seal**	cap, slnt
Judge 3	S	**seal**	stop, fix

Inter-rater Reliability

Many ways to measure agreement…

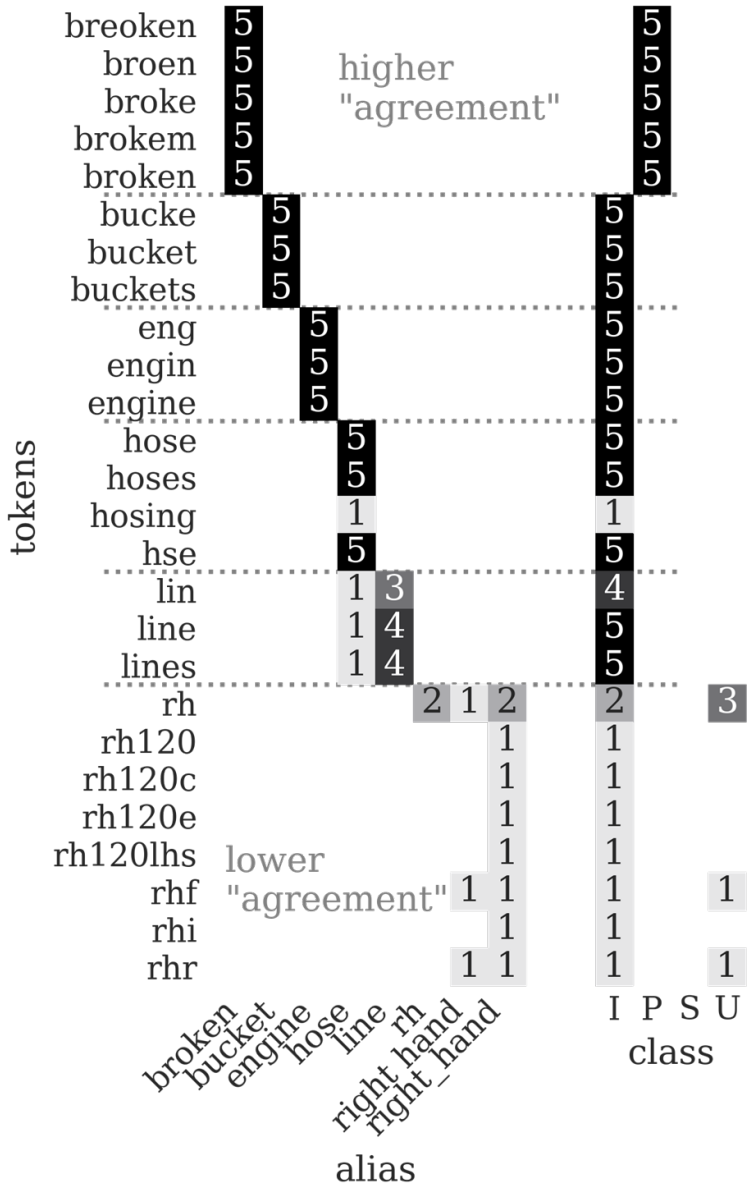
- Correlation coefficients
- Kappa-statistics
- Krippendorf’s alpha

Tagging Exercise

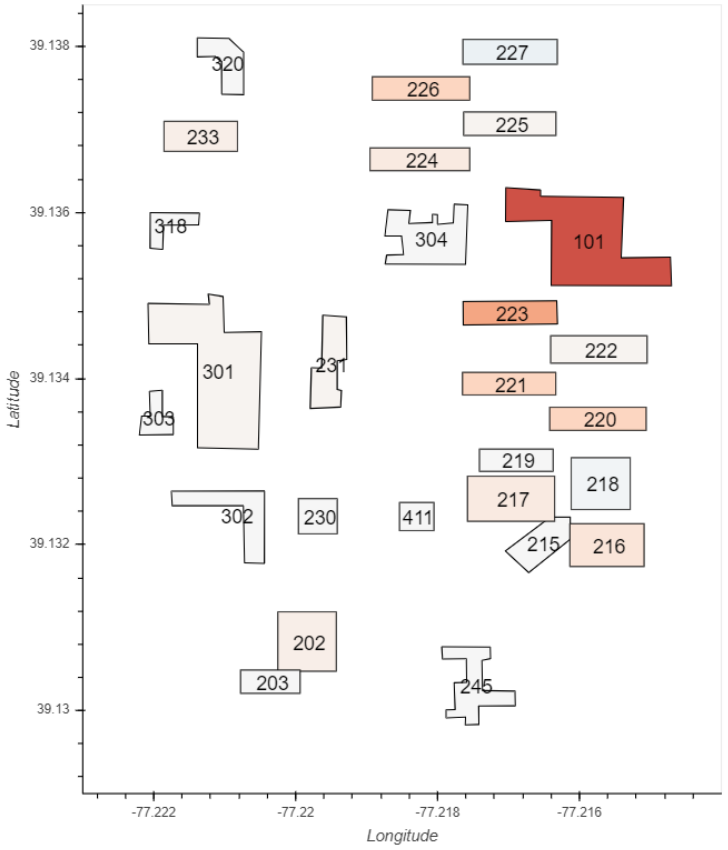
Input Matrix Sample

- Mapping of input tokens → alias annotation
- Many high-importance words have high-agreement
- Domain-specific ambiguity reduces agreement *slightly*, possible due to unfamiliarity.
- Variations on a “theme”: low-frequency synonyms/patterns (“rh”)

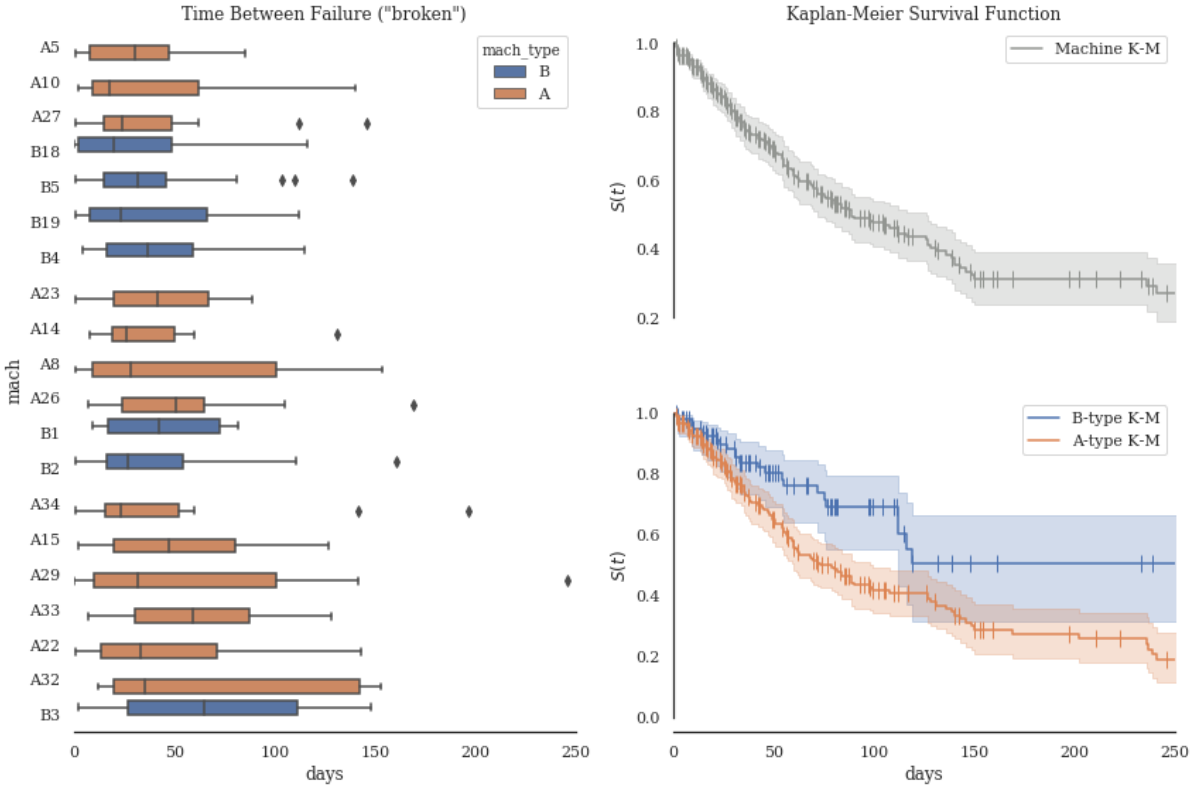
1. Hard to access by all users
2. Unclear level of abstraction



Analysis



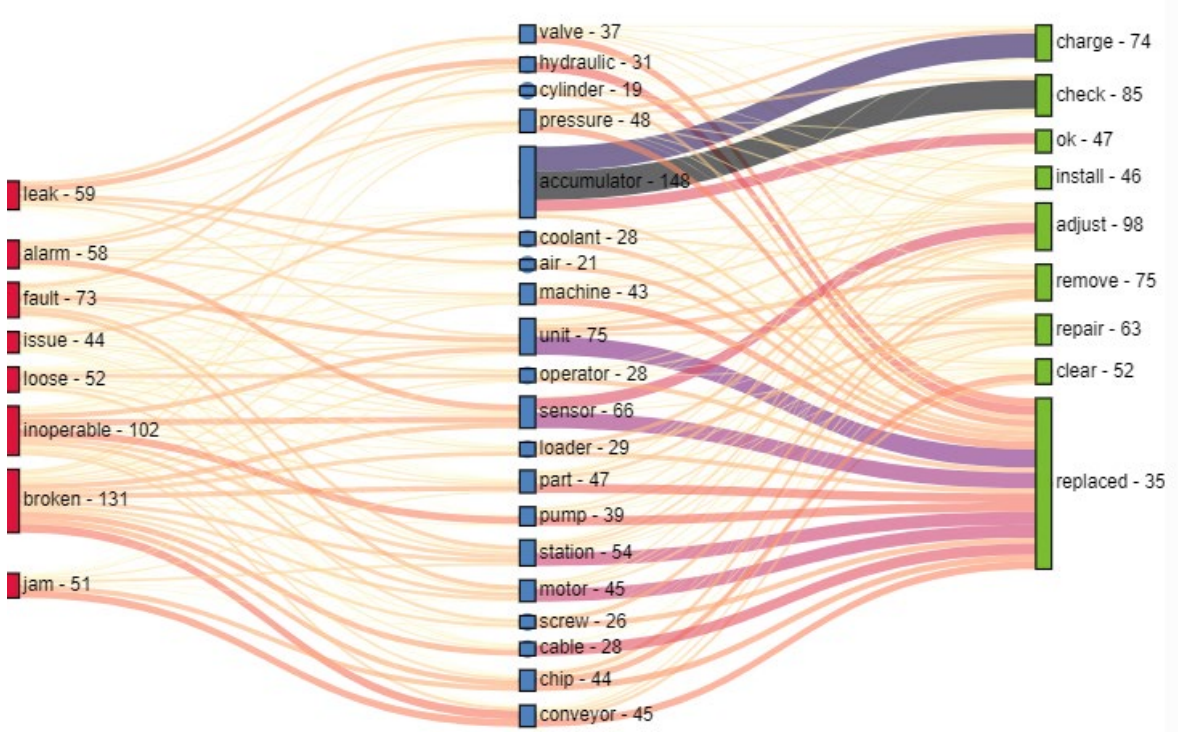
Identify problem hotspots using a heatmap



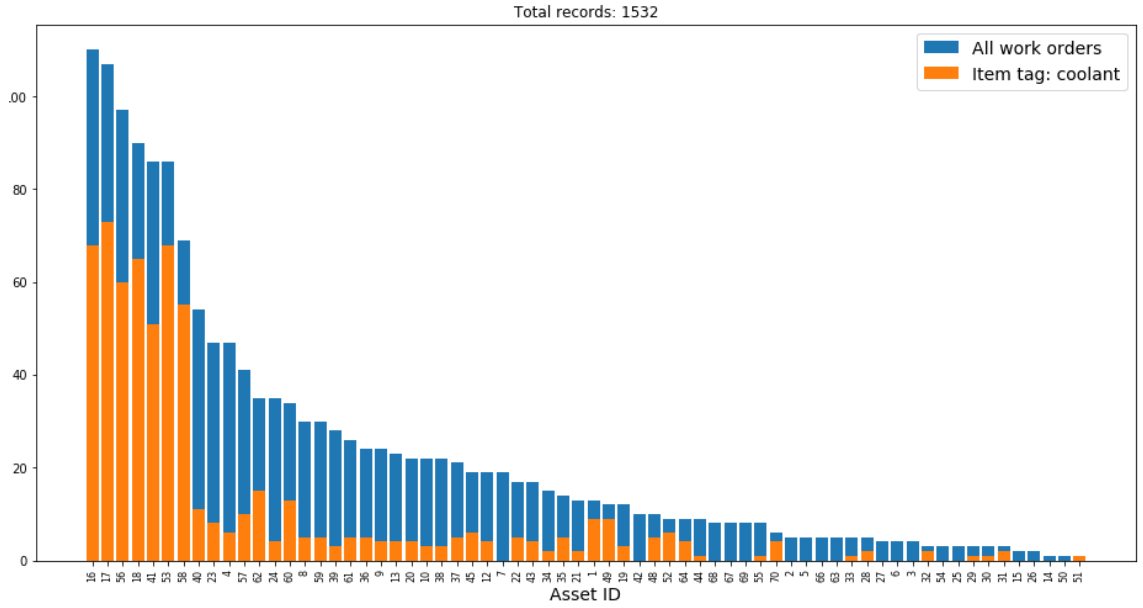
Determine survival functions for different assets

Analysis

Find linkages between problems-items-solutions



Analyze items with most issues across various assets



Future Work

- Provide publicly available datasets
- Create guidelines for tagging and analysis pipelines
- Open-source tools for analysis and visualization
- Need more feedback and community involvement with Nestor
  - https://www.nist.gov/services-resources/software/nestor