Identifying leading indicators of product recalls from online reviews using positive unlabeled learning and domain adaptation

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Motivation

- The U.S Consumer Product Safety Commission (CPSC) is charged with safeguarding the public from hazardous products, but the thousands of products under their jurisdiction make it challenging to identify & respond to consumer complaints quickly and issue product recalls.
- From the consumer's perspective, online reviews can provide evidence of product defects, but manually sifting through hundreds of reviews is not always feasible.

Goals: (1) Identify Amazon reviews indicating health or safety hazard

(2) Aggregate reviews to identify products that may be recalled

Data

1. Amazon product reviews [McAuley et al. '15]: 915,446 "Baby" reviews, August 2008-July 2014.
2. CPSC complaints database: 2010 "Babies and kids" complaints in *SaferProducts.gov* from March 2011 – May 2016.
3. Labeled Review Data: For validation, annotated 448 Amazon reviews : 97 positive (hazardous) reviews and 351 negative (non-hazardous) reviews.
4. Recall Database: Products recalled by CPSC that had reviews in the Amazon data. 137 Amazon products matched 47 recall records.

Methods

1. Baseline method: Positive Unlabeled Learning [Li & Liu '05]

Positive examples from one domain

Unlabeled examples from another domain assumed to be negative

- Logistic regression
- Restrict negative examples to those with star rating > τ

Problem: Selection Bias

- Some products more common in complaints data (cribs, night lights, gates)

2. Proposed method: Informed prior

- **Solution:** Increase feature values for terms that correlate with positive instances in Amazon product reviews.
- Since we don't know which reviews are positive, we estimate with the baseline classifier.

"This crib is very dangerous"

"crib"	"is"	"very dangerous"	"zebra"	"very"
1	1	1	0	1
		↓		
1.2	1.01	17.4	0	1.5

$$p(y = 1 \mid x_i = 1) \approx \frac{C(\hat{y} = 1 \wedge x_i = 1)}{C(x_i = 1)}$$

$C(\cdot)$ document count

x_i feature i

$\hat{y}$ class label predicted by baseline classifier

- With additional transformations, we scale probabilities for each term to be non-negative & have mean = 1.

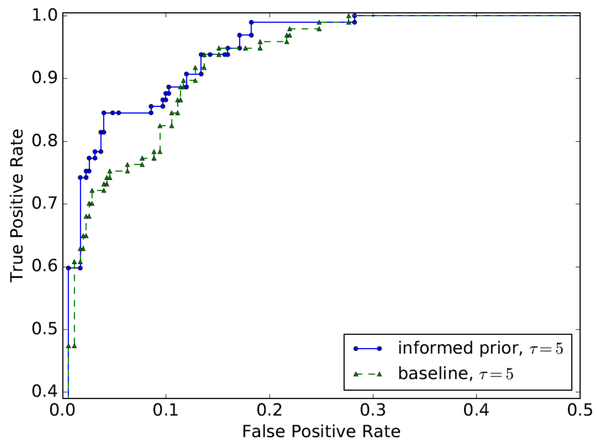
Results

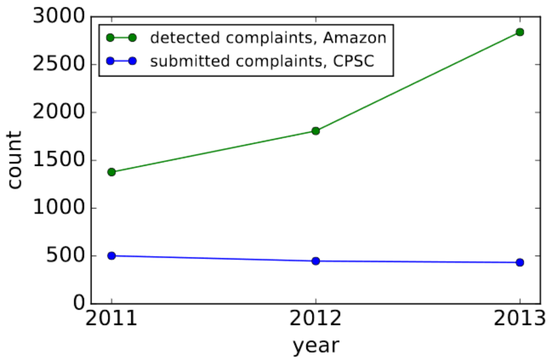
Model	Top terms
Baseline	mold, *pampers*, fell, *crib*, rock, dangerous, *night light*, hazard, broke, happened, *gate*, rash, *light*, recall, *model*, stuck, unsafe, caused, noticed, choking
Informed prior	very dangerous, cpsc, mold, smacked, swallow it, emergency room, recalled, recall, was playing, hazard, is unsafe, snapped, leaned forward, the consumer, got stuck, was hanging, burnt, injured, exploded, was chewing

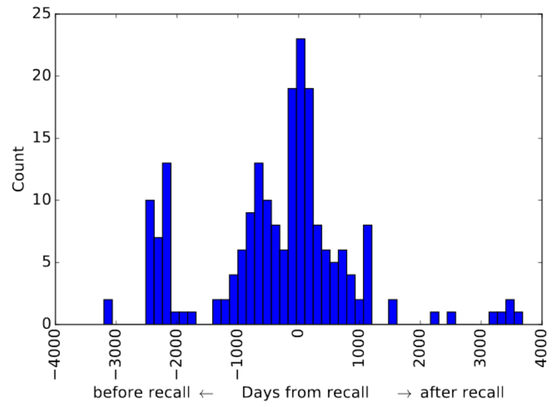
Model	Review Threshold (τ)	ROC AUC	F1	Precision	Recall
informed prior	5	**97.0** $\pm$ 0.10	**84.3** $\pm$ 0.42	85.8 $\pm$ 0.90	**82.8** $\pm$ 0.28
informed prior	4	96.4 $\pm$ 0.19	82.7 $\pm$ 0.47	86.8 $\pm$ 0.35	79.0 $\pm$ 0.56
informed prior	3	96.3 $\pm$ 0.09	82.1 $\pm$ 0.41	**87.6** $\pm$ 0.16	77.3 $\pm$ 0.84
baseline	5	96.1 $\pm$ 0.08	75.3 $\pm$ 0.43	72.8 $\pm$ 0.57	78.0 $\pm$ 0.28
baseline	4	95.9 $\pm$ 0.01	74.8 $\pm$ 0.36	73.7 $\pm$ 0.76	75.9 $\pm$ 0.28
baseline	3	95.7 $\pm$ 0.06	76.4 $\pm$ 0.54	78.4 $\pm$ 0.86	74.6 $\pm$ 0.28
baseline	none	94.0 $\pm$ 0.05	70.0 $\pm$ 0.24	79.0 $\pm$ 0.95	62.9 $\pm$ 0.97

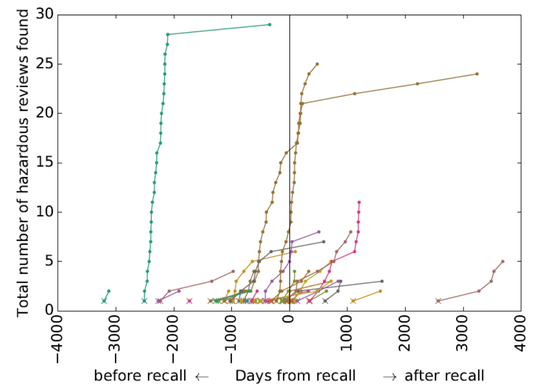
Comparison of the baseline classifier with our informed prior method on the validation data (with standard errors).

Identified a hazardous review prior to recall date for 45% of recalled products.









Product Name	Recall Date	Recall Reason	Review Date	Review Snippet
Contours Options Tandem Stroller	2012-07-24	"...the front wheel assembly can break, posing a fall hazard to the child in the stroller" [a]	2010-12-10 (592 days prior)	"...after less than 4 months of use, it fell apart: the front end collapsed because the two pins holding it in place popped out...I contacted Kolcraft immediately and nearly a month later I still don't have a working stroller."
Phil & Teds Travel System Car Seat Adaptor	2014-06-04	"the plastic adaptors used to connect an infant car seat to a stroller can crack, become unstable and break during use, posing a fall hazard to infants." [b]	2013-04-30 (400 days prior)	"I'm not sure if this attachment has a defect or if it is only supposed to have one button on the adapter, but it makes the carseat very wobbly and unstable...Is mine defective? Everyone else seems to have great reviews, but mine is so unstable it seems dangerous.
Fisher-Price Rainforest Infant Swing	2007-05-30	"infants can shift to one side of the swing and become caught between the frame and seat, posing an entrapment hazard." [c]	2007-01-14 (136 days prior)	"It's a very poor design and needs a LOT of work. And my daughter ends up in a crumbled up ball on one side of the swing more times than not."

Demo / code / data

https://shreeshbhat.github.io/recalls