MULTI-INSTANCE DOMAIN ADAPTATION FOR VACCINE ADVERSE EVENT DETECTION

Junxiang Wang and Liang Zhao

The 27th International World Wide Web Conference (WWW)

Content

- Introduction
- Challenges
- Our Framework
- Optimization
- Experimental Results

Introduction: Background.

- Vaccine does protect people from being infected, but vaccination can cause adverse reactions in large populations.

  - 25.8 percent of adverse events, including one diagnosed as pneumonia, were reported from a recent Influenza A (H1N1) vaccination program in Korea.

  - A woman died of multiorgan failure and respiratory distress, which is clinically verified to be caused by a yellow fever vaccination in Spain on October 24, 2004.

- Formal reporting systems suffer from poor timeliness.

  - Vaccine adverse event reporting system release reports every three months.

Introduction: Be aware of side effect of medicines

- The advantages and disadvantages of social media and vaccine adverse event reporting system on the healthcare applications.

	Advantages	Disadvantages
Social media	Message timeliness	Prohibitive labeling efforts
	Senor ubiquity	Class imbalance
Vaccine adverse event reporting system	Accurate labels	Poor timeliness

- Idea: Integrate their complementary strengths!

Challenges: 1. Formal language versus informal language.

Report ID	Formal report	Twitter user ID	Tweet
617010	The patient started to feel an **itching** feeling.(+)	641253	1. Flu shots in Town Lobby from 1-5 pm.(-) 2. A flu shot for only 12 dollars.(-) 3. Gettin' a flu shot!(-)
617014	Swollen **parotid glands**, fever, headache, **malaise**.(+)	5374	1. **Ouch**! So sore my arms are! **Damn** flu shot! (+) 2. Also. i went and got the flu shot, cause i thought they give you orange drink and biscuits afterwards. (-) 3. Should have taken flu shots! Who knew?(-)

Formal words and professional terms.

Informal words

Challenges: 2. Single text versus multiple messages.

Report ID	Formal report	Twitter user ID	Tweet
617010	The patient started to feel an **itching** feeling.(+)	641253	1. Flu shots in Town Lobby from 1-5 pm.(-) 2. A flu shot for only 12 dollars.(-) 3. Gettin' a flu shot!(-)
617014	Swollen **parotid glands**, fever, headache, **malaise**.(+)	5374	**1. Ouch**! So sore my arms are! **Damn** flu shot!(+) 2. Also. i went and got the flu shot, cause i thought they give you orange drink and biscuits afterwards. (-) 3. Should have taken flu shots! Who knew?(-)

Single text per user

Multiple messages per user

Challenges: 3. One class versus binary classes.

Report ID	Formal report	Twitter user ID	Tweet
617010	The patient started to feel an **itching** feeling.(+)	641253	1. Flu shots in Town Lobby from 1-5 pm.(-) 2. A flu shot for only 12 dollars.(-) 3. Gettin' a flu shot!(-)
617014	Swollen **parotid glands**, fever, headache, **malaise**.(+)	5374	**1. Ouch**! So sore my arms are! **Damn** flu shot! (+) 2. Also. i went and got the flu shot, cause i thought they give you orange drink and biscuits afterwards. (-) 3. Should have taken flu shots! Who knew?(-)

Only positive class

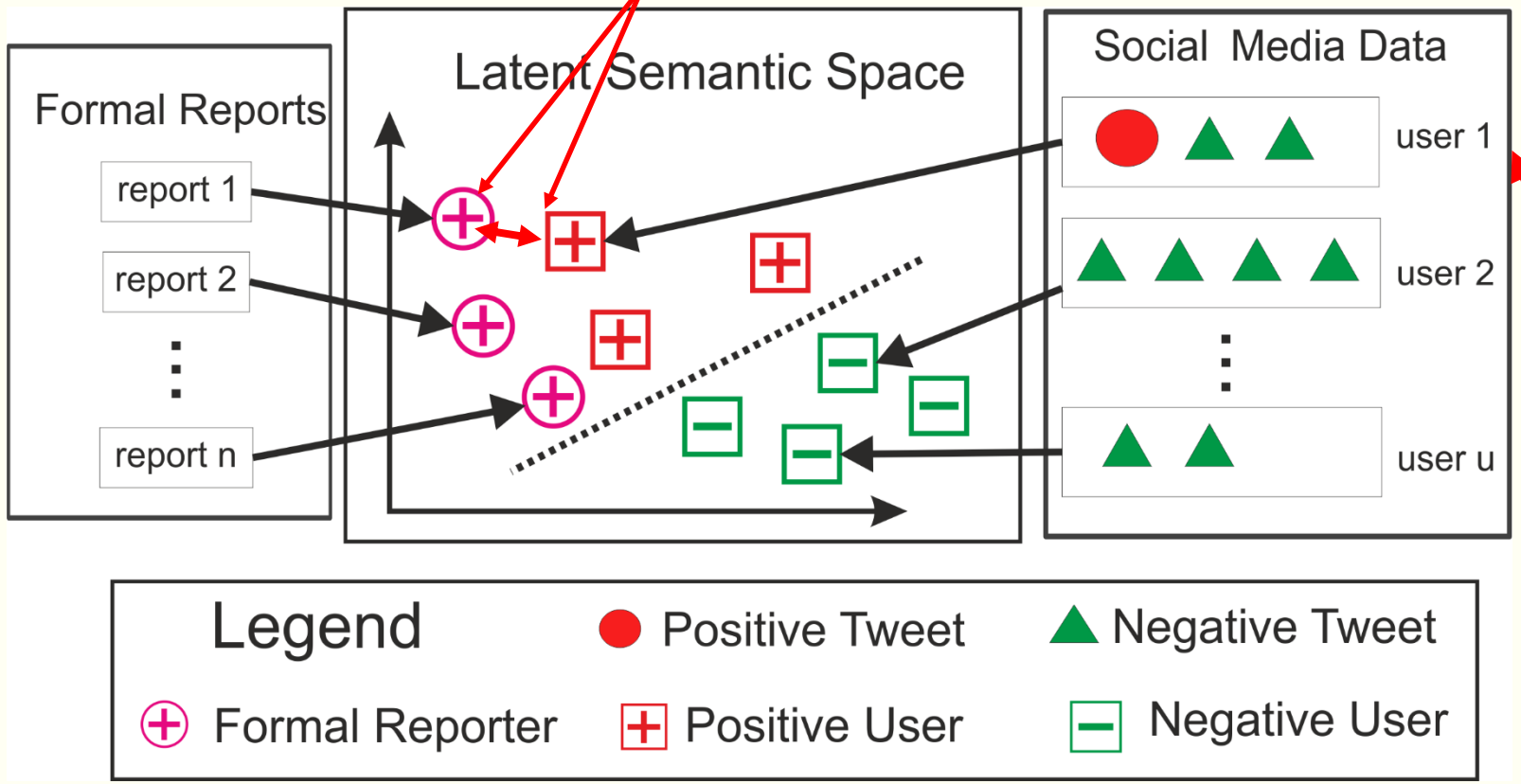
Both positive and negative classes

Our Framework: Multi-instance Domain Adaptation (MIDA).

A generalized Maximum Mean Discrepancy (MMD) criterion:

$$\min Dist^2(R, U_p; \beta) = \min \left\| \frac{\phi(R)}{r} - \frac{\phi(U_p)}{n_p} \right\|_H^2 .$$

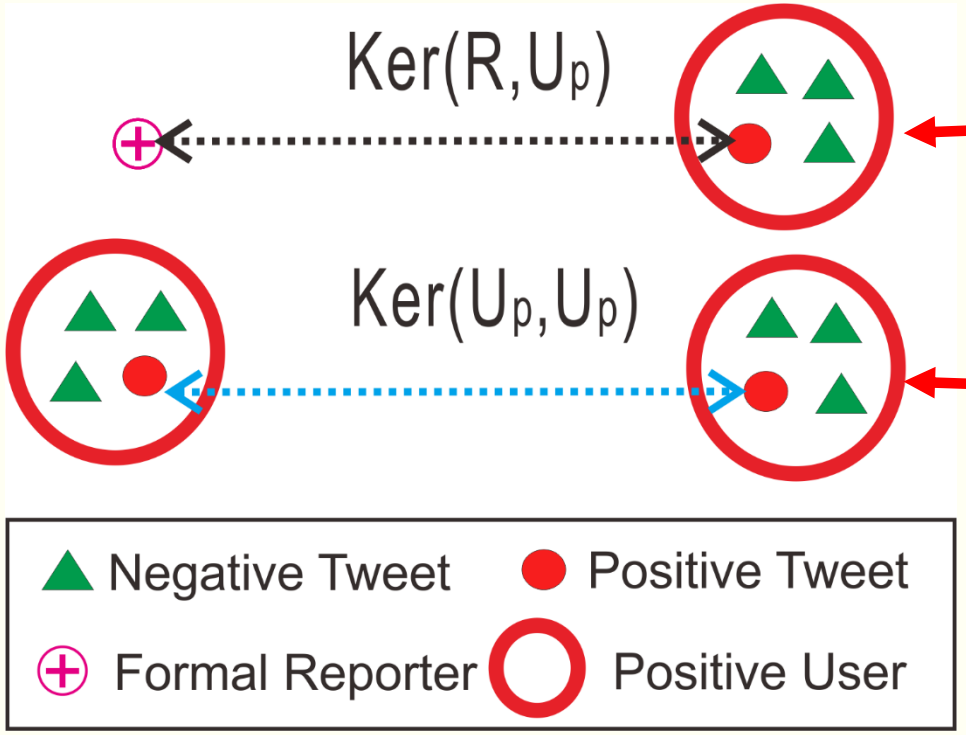
R: The formal report set.
r: The number of formal reports.
U_p: The positive user set.
n_p: The number of positive users.
β: The coefficient of the classifier.
$\phi(\cdot)$: A feature mapping from formal report space and social media space to latent semantic space.



The max rule: a positive tweet is indicative of a positive user.

Our Framework: Mixed instance kernels.

- The generalized MMD criterion entails the design of mixed instance kernels.



The mixed instance kernel $Ker(R, U_p)$ is determined by the similarity between formal reports and positive tweets.

The mixed instance kernel $Ker(U_p, U_p)$ is determined by the similarity between two positive tweets.

R: The formal report set.
U_p: The positive user set.

Optimization: Objective function.

$$min_{\beta} \sum_{i=1}^{n} Loss_u(\beta) + \lambda_1 \Omega(\beta) + \lambda_2 Dist^2(R, U_p; \beta)$$

Empirical loss

Regularization term

Generalized MMD criterion

- This problem is nonconvex and solved by Alternating Direction Method of Multipliers(ADMM) combined with Convex-Concave Procedure(CCP).

Experimental Results: Dataset

- *Twitter data: Two-stage data collection.*

  - *The first stage: Tweets related to the topic "flu shot" were queried by 113 keywords. A total number of 11,993,211,616 tweets for the period between Jan 1,2011 and Apr 15,2015 in the United States were retrieved. Twitter users who received flu vaccination were identified using the LibShortText text filter.*

  - *The second stage: Tweets from users who were identified to receive flu vaccination were queried again within 60 days since they received vaccination. The Twitter dataset contained 41,438 tweets from 1,572 users where 566 were labeled as positive and 1,006 were negative.*

- *Formal report*

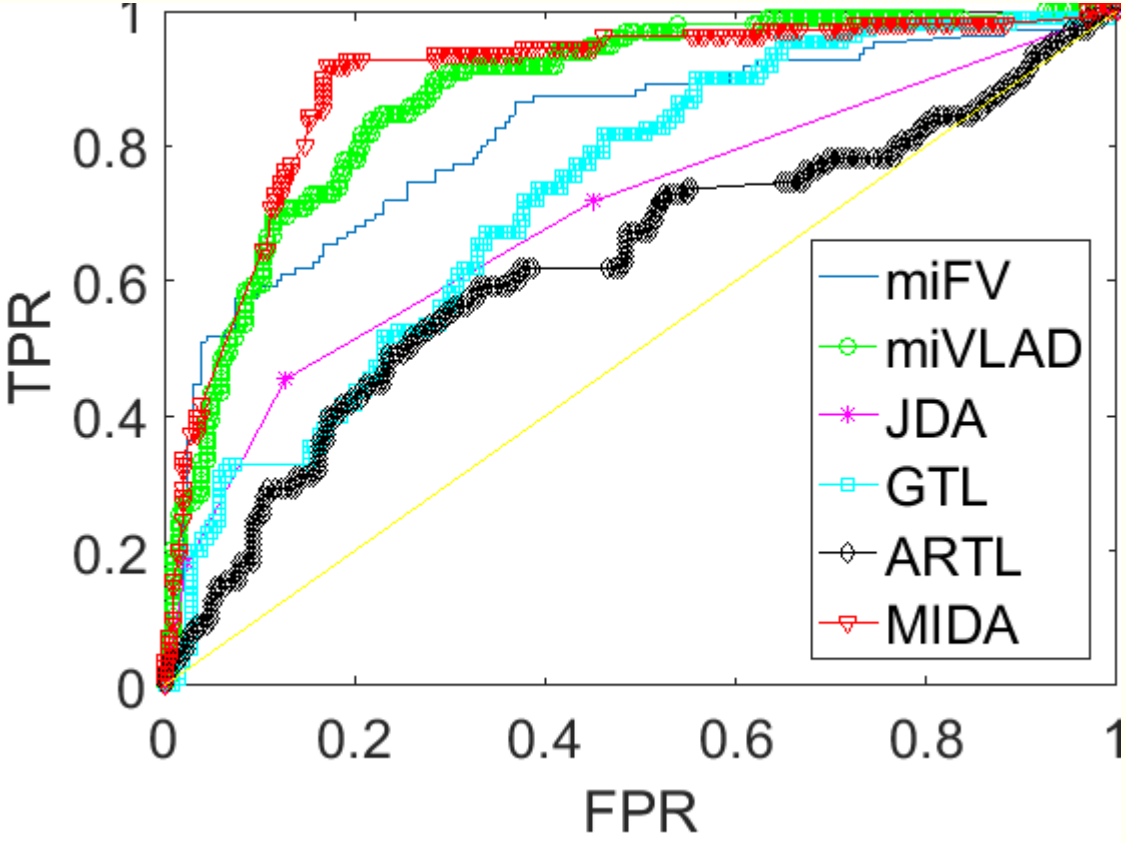
  - *the raw data was downloaded from the Vaccine Adverse Event Reporting System (VAERS) for the year 2016. The symptom text column contained adverse event descriptions. 2500 formal reports were extracted.*

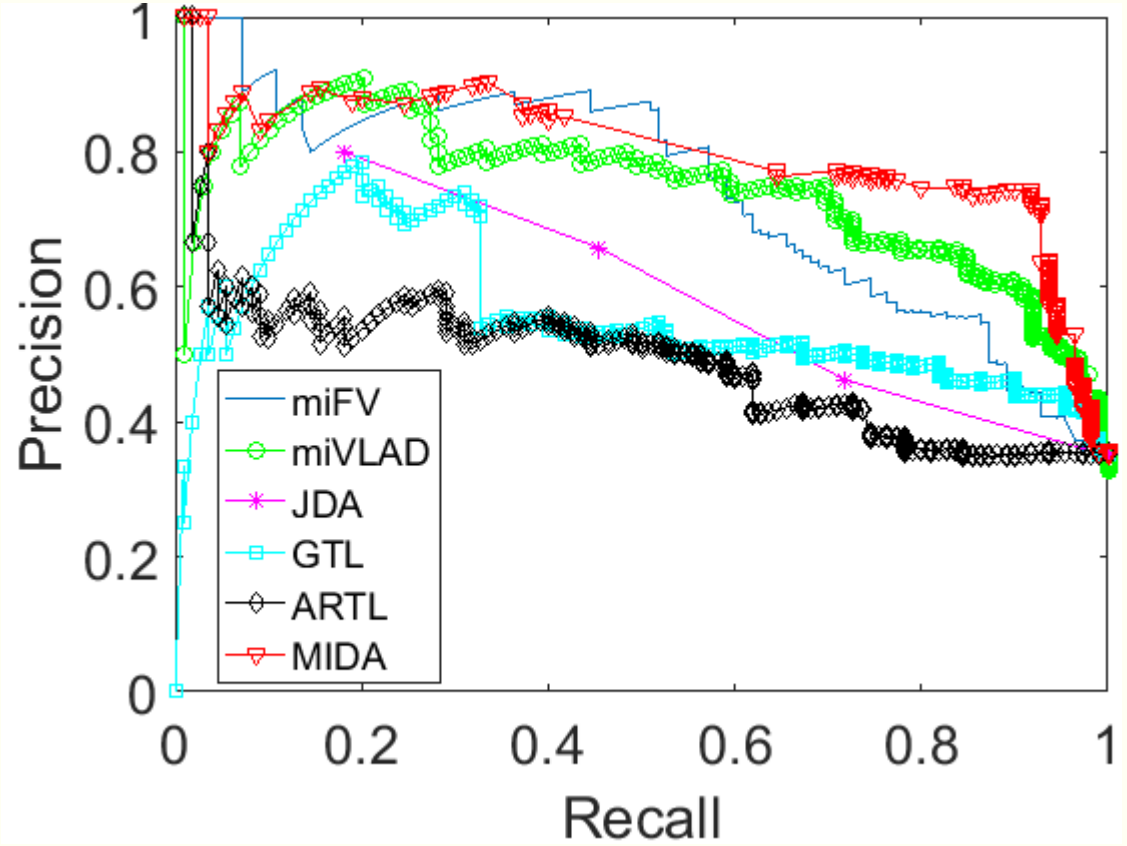
Experimental Results: Vaccine adverse event detection.

	Methods	Accuracy	Precision	Recall	F-score	Area under ROC curve	Area under PR curve
Multi-instance learning	miFV	0.7754	0.7321	0.5965	**0.6570**	0.8451	0.7584
	miVLAD	0.7614	0.6882	0.6245	0.6535	0.8227	0.7053
Transfer learning	JDA	0.7163	0.6370	0.4938	0.5552	0.7091	0.4652
	GTL	0.6158	0.4215	0.2061	0.2750	0.6310	0.4905
	ARTL	0.5356	0.4108	**0.6435**	0.5003	0.5997	0.4494
	MIDA	**0.7767**	**0.7735**	0.5333	0.6310	**0.8530**	**0.7642**

- MIDA ranked the first in four metrics out of six.
- Multi-instance learning methods outperformed transfer learning methods.

Experimental Results: ROC curve and PR curve.





- MIDA performed the best in general.
- Multi-instance learning methods outperformed transfer learning methods.

Experimental Results: Case study.

Symptoms	Formal reports	Adverse-relevant tweets extracted by MIDA
arm pain	Arm pain for >7 days, sought medical treatment at clinic.	Not only did I fall down the steps, but I got my flu shot and my arm is sore.
shoulder and neck pain	overall aches and pain, but especially in back shoulder blade area and neck	got my flu shot 30 minutes ago and the SERIOUS ache is spreading to my shoulder into my neck.
headache	An hour after getting the shot he got a headache and then started throwing up.	I feel that headache slowly coming back after getting shots.
runny nose	Pt received vaccine on 12/11/15.12/14/15 diarrhea, runny nose, cough.	Damn flu shots! now my nose startin to run.
throat pain	Shortly after patient was vaccinated, she started to feel an itching, tingling feeling in her throat.	Just got a shot! i dnt wanna get sick! I already have a sore throat now.

Thank you. Any questions?