Forecasting Heroin Overdose Occurrences from Crime Incidents

Ali Mert Ertugrul[1,2], Yu-Ru Lin[1], Christina Mair[1], Tugba Taskaya Temizel[2]
[1]University of Pittsburgh, PA, USA
[2]Middle East Technical University, Ankara, Turkey

Motivation

- Opioid overdose rates in the US have increased at an alarming rate since the past decade.
- Forecasting opioid overdose occurrences may enhance the overdose surveillance and identify the areas in need of prevention effort.
- Theoretical motivation: studies suggested different types of links between the overdose occurrences and criminal activities, such as financial motives and common causes.

Aims: to explore forecasting capability of overdose events using real-time crime data:

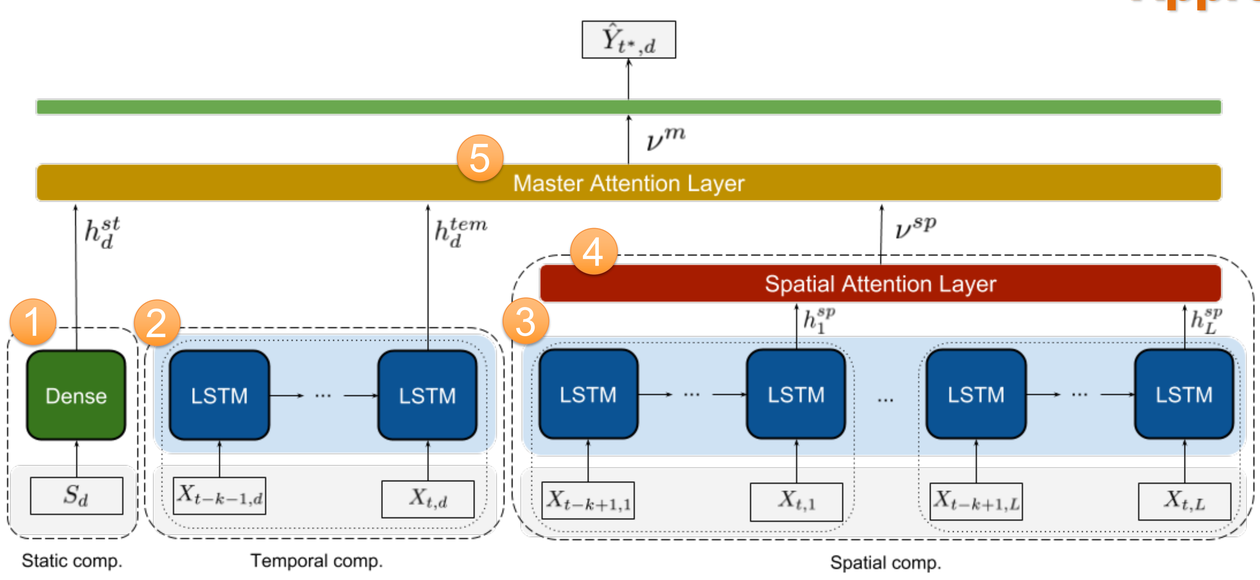
- model the spatiotemporal patterns of the crime incidents to forecast future heroin overdose occurrences;
- identify informative static and dynamic features on forecasting overdose occurrences;
- discover the predictive hotspot neighborhoods;
- examine the contribution of local and global crime dynamics, and static features on forecasting future overdose occurrences.

Achieve these aims via an inductive, end-to-end trainable model.

Data and Features

- Cincinnati Heroin Overdose Dataset
  - Monthly overdose incidents between August 2015 – May 2018
  - Used as target variables employed in forecasting
- Cincinnati Police Data Initiative Crime Incidents Dataset
  - Monthly crime incidents between August 2015 – May 2018
    - Theft, Burglary / Breaking – Entering, Robbery, Aggravated assault, Rape, Minor crimes, and Unauthorized use
  - Used as dynamic features to forecast opioid overdose
- US Census 2010 Data (Cincinnati Statistical Neighborhood Approximations)
  - Population, demographics (gender, race) and economic status (low median income, per capita income, poverty)
  - Used as static features to forecast opioid overdose

Approach



1. Static component: encodes static features of the target location.
2. Temporal component: encodes local crime dynamics of the target location.
3. Spatial component: encodes spatiotemporal crime dynamics of all locations.
4. Spatial attention layer: identifies the predictive hotspot neighborhoods.
5. Master attention layer: differentiates the contributions from static, local dynamic and global dynamic feature contributions.

Analysis of Features

Population	0.304
Gender (male ratio)	0.459
White alone	0.213
Black or African Am. alone	0.166
Am. Ind. or Alaska Nat.	0.001
Asian alone	1.354
Nat. Haw. and Other Pac. Isl. alone	0
Two or More Races	0.226
Hispanic	1.019
Median Household Income	0.423
Per Capita Income	0.403
Poverty	0.609

Static feature weights

No_Unique_Incidents	0.384
No_Incidents_UCR_Groups	0.279
Part_2_Minor	0.561
Theft	0.484
Burglary/Breaking Entering	0.450
Robbery	0.144
Aggravated Assaults	0.080
Rape	0.085
Unauthorized Use	0.099

Local dynamic feature weights

Our findings are consistent with the literature:

- A lack of economic resources in communities is associated with greater vulnerability to substance use.
  - Communities with a higher concentration of economic stressors (e.g., low median income) may be particularly vulnerable to abuse of opioids as a way to manage chronic stress and anxiety and mood disorders.
- Theories of the drugs-crime connection predict that certain kinds of offenses, such as shoplifting, theft, robbery, burglary and prostitution are more likely than others to be associated with drug use and they might be committed to raise funds to purchase drugs.

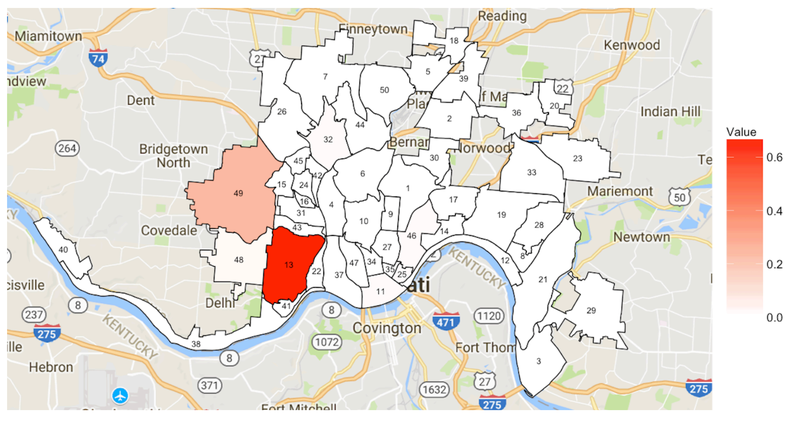
Evaluation

- Training: data within the first 2 years
- Validation: data within the next 3 months
- Test: data within the last 5 months

	RMSE	MAE	Pearson	Spearman's Rank
Baseline	2.954	2.003	0.701*	0.691*
Our model	**2.672**	**1.473**	**0.715***	**0.722***

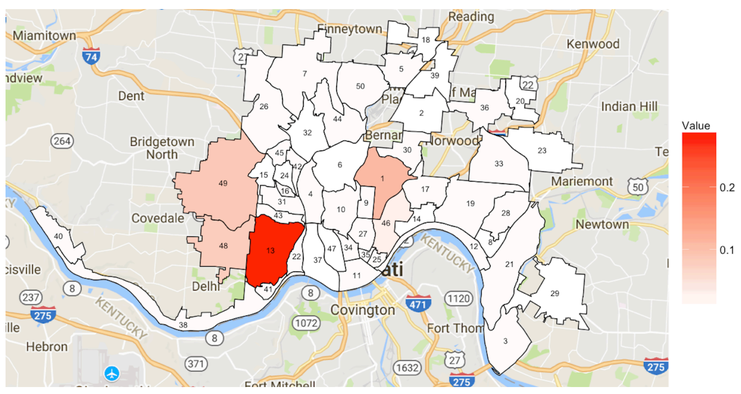
* $p < 0.001$

Predictive Hotspot Neighborhoods

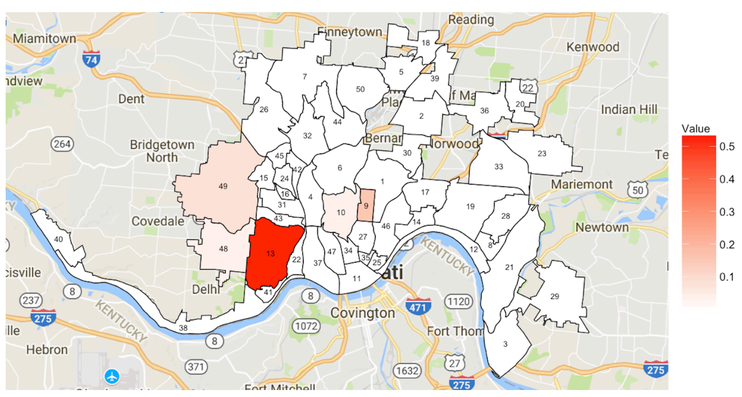


- The neighborhoods colored with darker red have more global contribution on forecasting heroin overdose occurrences on the other neighborhoods.
- The globally most contributing neighborhoods are:
  East Price Hill (13), Westwood (49)
- The neighborhoods with little contribution on forecasting are:
  West Price Hill (48), Walnut Hills (46)
- Remaining neighborhoods do not have significant contribution on forecasting overdose occurrences.

Change in Predictive Hotspot Neighborhoods



Aug 2015 – Dec 2016



Jan 2017 – May 2018

- The common predictive hotpots for both time intervals are:
  East Price Hill (13), Westwood (49), West Price Hill (48)
  These neighborhoods continued to have the highest crime incidents among all the neighborhoods.
- Additional predictive hotspots before 2017 are:
  Avondale (1), Walnut Hills (46)
  Their crime incidents decreases after 2017.
- Additional predictive hotspots after 2017 are:
  Corryville (9), CUF (10)
  The number of crime incidents in Corryville increases after 2017.
- The change in predictive hotspots reflects the change of crime activity.

Contact: {ertugrul,yurulin}@pitt.edu