Final Project Proposal:

Crime Forecasting using Satellite Imagery

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Crime Forecasting

- Predict future high-risk crime areas (hot spots) through past spatial and temporal information
- Prediction Tasks:
  - Classification (Hot spot forecasting):
    - crime/no crime *[1]*; theft/no theft *[2]*;
  - Related Statistics Prediction:
    - Number of crimes *[4]*, most-likely crime type, etc. *[6]*
- Features:
  - Location (address / lon&lat), time, type, etc.

Literature Reviews and Motivations

- *Crime Hot Spot Forecasting: A Recurrent Model with Spatial and Temporal Information [1]*
  - Feature: Simply feed lon, lat;
  - Task: forecast crime hot spots;
- *Grid-Based Crime Prediction Using Geographical Features [2]*
  - Feature: Generate geographical features;
  - Task: Only predict vehicle theft;
- ***Crime Mapping from Satellite Imagery via Deep Learning [3]***
  - Feature: Use raw satellite imagery, **no temporal info**;
  - Task: Predict violent crime rate at three levels (low, neutral, high);
- ***Examine Deep Learning Architectures for Crime Classification and Prediction [4]***
  - Feature: Generate incident maps;
  - Task: Both multi-label hot spot classification and prediction

Motivation: Satellite Imagery *[3]*

- Visual features contained in satellite imagery can be successfully used as a proxy indicator of crime rates

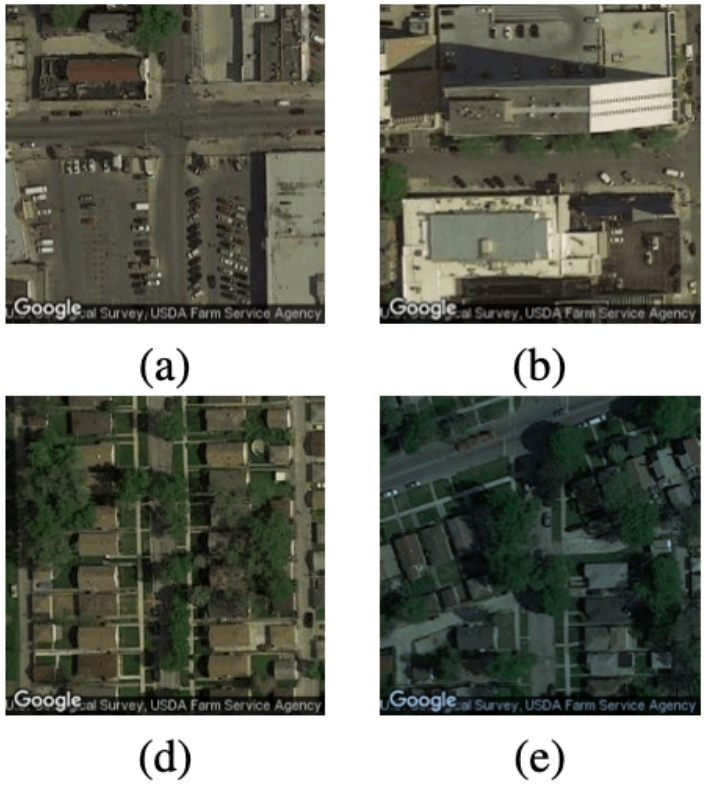

Figure 1: Satellite images of Chicago.
>100 crimes in (a), (b); 1 crime in (d), (e).

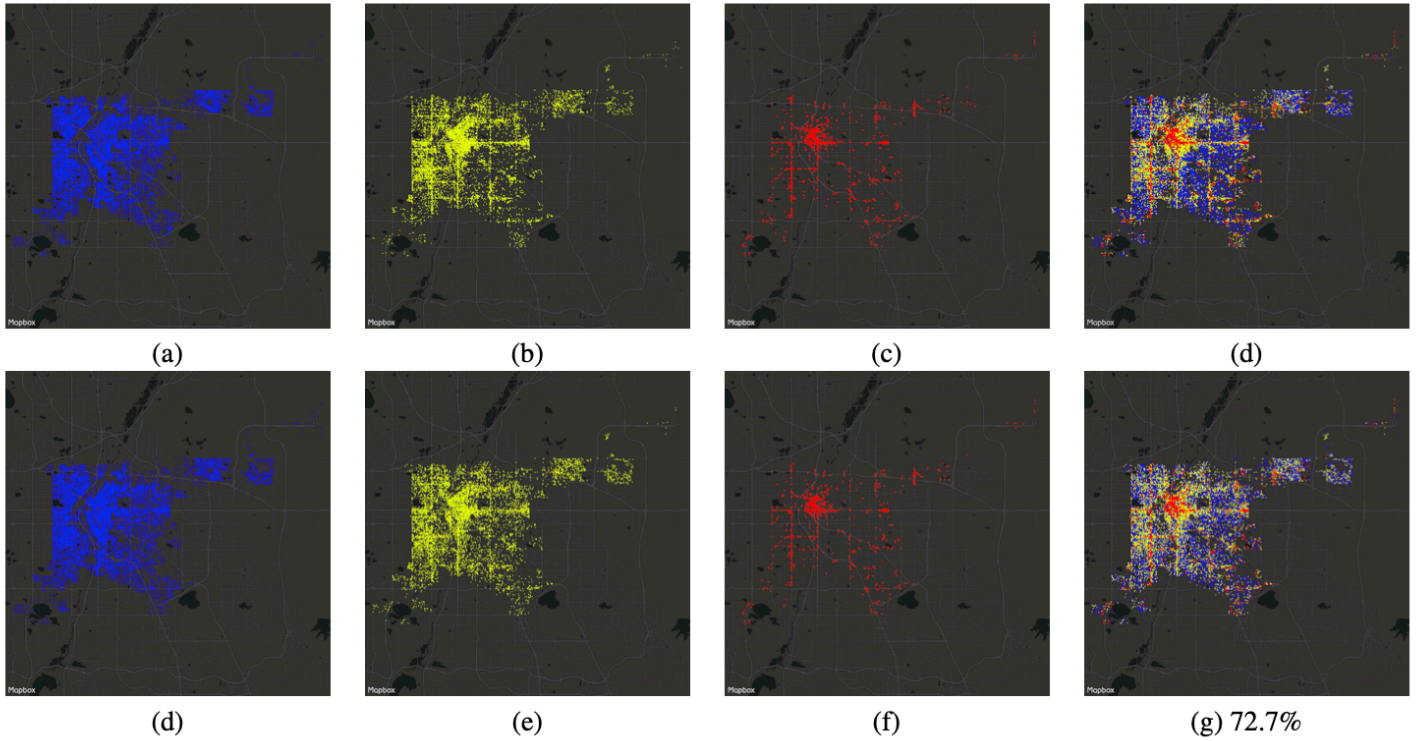

Figure 2: City-scale crime maps of Denver. (Crime rate label: low, neutral, high)

Literature Reviews and Motivations

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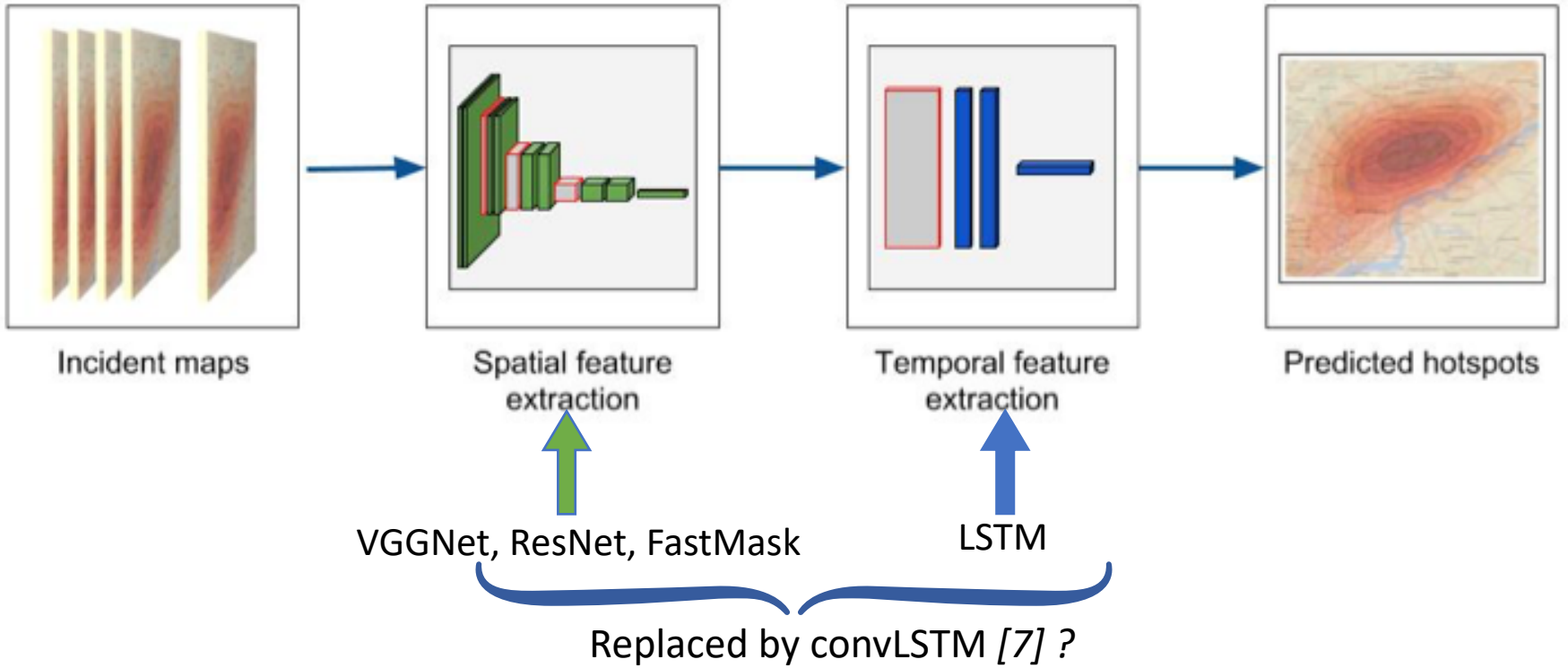
Motivation: Crime Classification and Prediction *[4]*

- Losses:
  - MSE for predicting number of all crimes
  - Multi-class cross entropy for predicting hot spot prob. of each crime type simultaneously
- Model: Spatial features first then the temporal (SFTT)



Proposed Work

- Features:
  - Add satellite image centered around center of each grid as **static** features
- Learning Tasks:
  - Crime classification and prediction simultaneously as in *[4]*
  - *Classification:
    - KL divergence for predicting the conditional distribution of crime type given that crime occurs in this cell
- Proposed method:
  - More survey (? pre-train a auto-encoder layer to learn a condensed feature embedding; AlexNet adopted in *[3]*)
  - Change the SFTT structure in *[4]* to convLSTM *[7]*

Possible Contributions

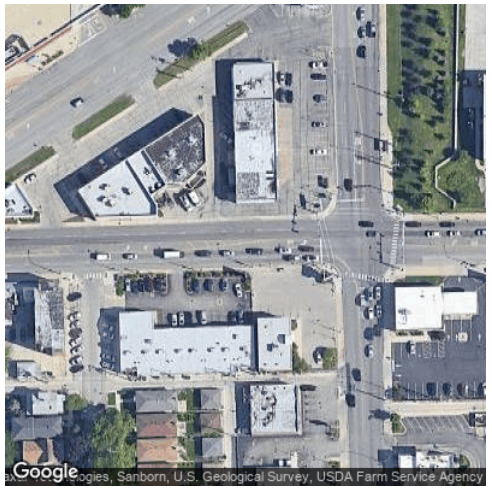
- Detect risk of all crime and each crime type to optimize and allocate policing resources more efficiently
  - Forecast hot spot map / heat map of crime
  - Forecast hot spot map / heat map of each crime type
  - Detect most-likely crime type

Dataset and Metrics

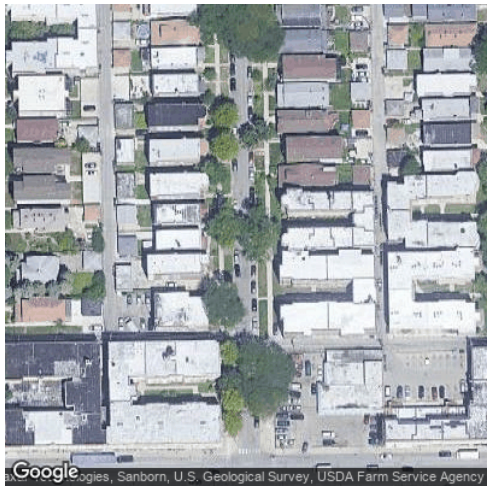
- Dataset:
  - Incident reports in Chicago from 2001 to present (https://data.cityofchicago.org/Public-Safety/Crimes-2001-to-Present/ijzp-q8t2)
  - Satellite imagery: Google Maps Static API (https://developers.google.com/maps/documentation/static-maps)
- Evaluation Metrics:
  - F1 score, AUROC, AUCPR, PAI@5 *[4]*
  - Compare with *[4]* (not good for multi-label prediction)

ID	Case Nu...	Date	Block	IUCR	Primary ...	Descript...	Location...	Arrest	Domestic	Beat	District	Ward	Commu...	FBI Code	X Coordi...	Y Coordi...	Year	Updated...	Latitude	Longitude	Location
12643551	JF175319	03/15/2022 1...	018XX S AVE...	0486	BATTERY	DOMESTIC B...	APARTMENT	True	True	1014	010	24	29	08B	1151031	1890714	2022	03/22/2022 0...	41.856008096	-87.721125022	(41.85600809...
12643574	JF175333	03/15/2022 1...	014XX S MCC...	1320	CRIMINAL DA...	TO VEHICLE	VACANT LOT ...	False	False	0132	001	3	33	14	1178518	1893492	2022	03/22/2022 0...	41.863048996	-87.620149927	(41.86304899...
12643663	JF175464	03/15/2022 1...	067XX W BEL...	1310	CRIMINAL DA...	TO PROPERTY	SMALL RETAI...	False	False	2511	025	36	18	14	1130711	1920518	2022	03/22/2022 0...	41.938167693	-87.795024502	(41.93816769...
12643518	JF175314	03/15/2022 1...	014XX S ST L...	143A	WEAPONS VI...	UNLAWFUL P...	ALLEY	True	False	1021	010	24	29	15	1153272	1892775	2022	03/22/2022 0...	41.861619576	-87.712844704	(41.86161957...
12646154	JF177555	03/15/2022 1...	056XX S ABE...	1320	CRIMINAL DA...	TO VEHICLE	VACANT LOT ...	False	False	0712	007	16	68	14	1169945	1867396	2022	03/22/2022 0...	41.791630164	-87.652379643	(41.79163016...
12643505	JF175317	03/15/2022 1...	070XX S CAR...	0486	BATTERY	DOMESTIC B...	APARTMENT	False	True	0733	007	6	68	08B	1170531	1858099	2022	03/22/2022 0...	41.766105333	-87.650501593	(41.76610533...
12643590	JF175369	03/15/2022 1...	001XX E 60T...	0488	BATTERY	AGGRAVATE...	APARTMENT	False	True	0311	003	20	40	04B	1178318	1865263	2022	03/22/2022 0...	41.785590911	-87.621742363	(41.78559091...
12643572	JF175323	03/15/2022 1...	076XX S SOU...	0420	BATTERY	AGGRAVATE...	RESIDENCE	False	False	0421	004	7	43	04B	1196793	1855308	2022	03/22/2022 0...	41.757834212	-87.554336279	(41.75783421...
12643535	JF175308	03/15/2022 1...	048XX W AR...	0820	THEFT	$500 AND U...	SIDEWALK	False	False	2522	025	36	19	06	1143972	1912866	2022	03/22/2022 0...	41.916931003	-87.74647932	(41.91693100...
12643599	JF175294	03/15/2022 1...	006XX N PAR...	0560	ASSAULT	SIMPLE	APARTMENT	False	False	1511	015	29	25	08A	1138568	1903672	2022	03/22/2022 0...	41.891801324	-87.76655704	(41.89180132...
12643533	JF175309	03/15/2022 1...	081XX S ING...	0486	BATTERY	DOMESTIC B...	APARTMENT	True	True	0631	006	8	44	08B	1183979	1851235	2022	03/22/2022 0...	41.746966294	-87.601424385	(41.74696629...
12643584	JF175327	03/15/2022 1...	021XX N LOR...	0454	BATTERY	AGGRAVATE...	RESIDENCE	False	True	2515	025	36	19	08B	1140372	1913689	2022	03/22/2022 0...	41.919256242	-87.759685645	(41.91925624...
12643643	JF175415	03/15/2022 1...	006XX E 51ST...	0910	MOTOR VEHI...	AUTOMOBILE	STREET	False	False	0223	002	4	38	07	1181313	1871333	2022	03/22/2022 0...	41.802178985	-87.610574294	(41.80217898...
12643913	JF175823	03/15/2022 1...	011XX N LEC...	0820	THEFT	$500 AND U...	STREET	False	False	1531	015	37	25	06	1142155	1907107	2022	03/22/2022 0...	41.901161592	-87.753298129	(41.90116159...
12643523	JF175297	03/15/2022 1...	021XX W RA...	1320	CRIMINAL DA...	TO VEHICLE	STREET	False	False	1223	012	27	28	14	1162201	1901194	2022	03/22/2022 0...	41.884540314	-87.67983259	(41.88454031...
12643573	JF175311	03/15/2022 1...	090XX S KIN...	0486	BATTERY	DOMESTIC B...	RESIDENCE	False	True	0423	004	7	48	08B	1194731	1845548	2022	03/22/2022 0...	41.731102964	-87.562213643	(41.73110296...
12643524	JF175320	03/15/2022 1...	003XX E 75T...	1310	CRIMINAL DA...	TO PROPERTY	TAVERN / LIQ...	True	False	0323	003	6	69	14	1179496	1855350	2022	03/22/2022 0...	41.758361783	-87.617725721	(41.75836178...

Figure 4: Data table preview



(a) Robbery



(b) Theft

Figure 5: Satellite images of Chicago

References

- [1] Zhuang Y, Almeida M, Morabito M, et al. *Crime hot spot forecasting: A recurrent model with spatial and temporal information*[C]//2017 IEEE International Conference on Big Knowledge (ICBK). IEEE, 2017: 143-150.
- [2] Najjar A, Kaneko S, Miyanaga Y. *Crime mapping from satellite imagery via deep learning*[J]. arXiv preprint arXiv:1812.06764, 2018.
- [3] Lin Y L, Yen M F, Yu L C. *Grid-based crime prediction using geographical features*[J]. ISPRS International Journal of Geo-Information, 2018, 7(8): 298.
- [4] Stalidis P, Semertzidis T, Daras P. *Examining deep learning architectures for crime classification and prediction*[J]. Forecasting, 2021, 3(4): 741-762.
- [5] Shah N, Bhagat N, Shah M. *Crime forecasting: a machine learning and computer vision approach to crime prediction and prevention*[J]. Visual Computing for Industry, Biomedicine, and Art, 2021, 4(1): 1-14.
- [6] Tabedzki C, Thirumalaiswamy A, van Vliet P, et al. *Yo home to Bel-Air: predicting crime on the streets of Philadelphia*[J]. University of Pennsylvania, CIS, 2018, 520.
- [7] Shi X, Chen Z, Wang H, et al. *Convolutional LSTM network: A machine learning approach for precipitation nowcasting*[J]. Advances in neural information processing systems, 2015, 28.