Territorial ratemaking with unsupervised embeddings

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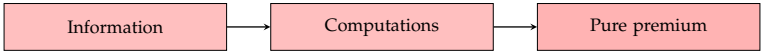
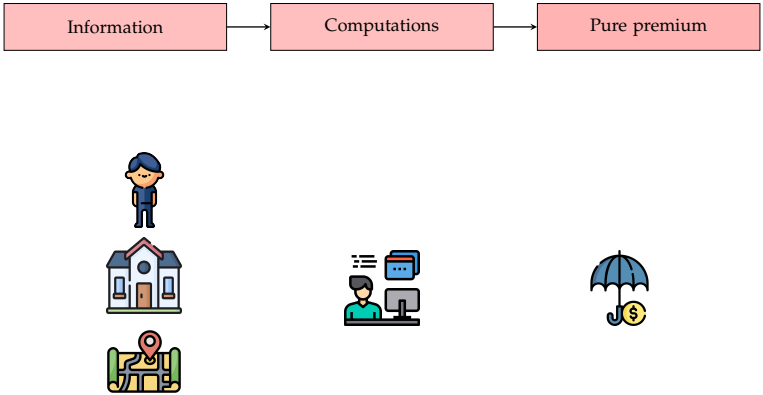
Quantact

Classical ratemaking



Territorial homeowners ratemaking



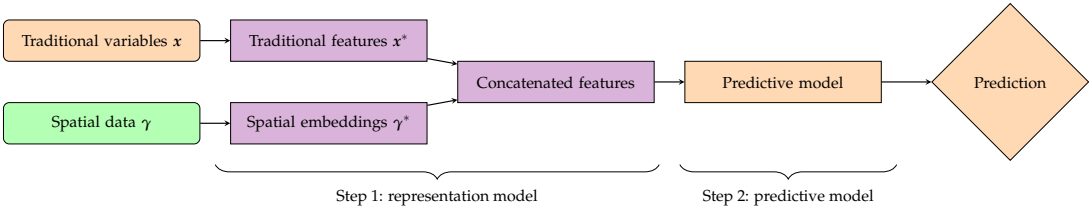
Territorial ratemaking

- Typical method for territorial ratemaking: spatial interpolation
  1. Smoothing risks based on coordinates (loess, splines, kriging, spRF)
  2. Averaging past losses based on polygons
- Control flexibility: compromise between credibility and homogeneity
  - Too flexible: few observations = noisy data, overfit
  - Too rigid: fail to capture local variations in spatial risk

Territorial ratemaking

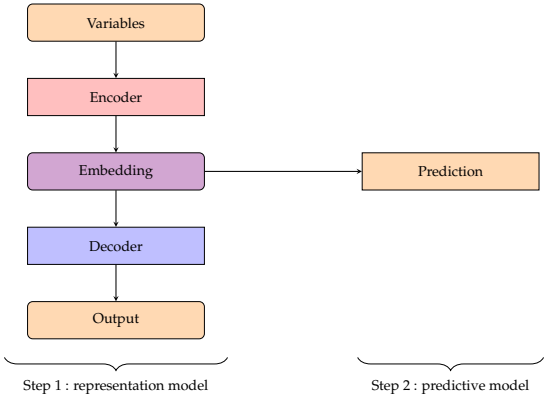
- Spatial embeddings = alternative to the credibility / homogeneity compromise
- Focus instead on what actually generates spatial risk
  - Landform
  - Weather
  - People
- Assumption: Since people generate risk, the spatial distribution of people relates to the spatial distribution of risk

Spatial embeddings



[Blier-Wong et al., 2020], [Blier-Wong et al., 2021b]

Spatial embeddings



[Blier-Wong et al., 2021a]

Spatial embeddings

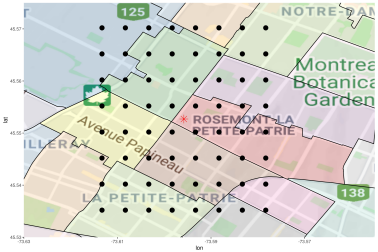
Desirable attributes of spatial embeddings

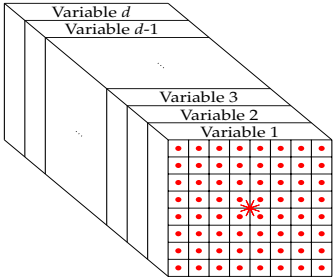
- We define three desirable attributes for spatial embeddings
  1. Spatial embeddings must follow Tobler's first law of geography
  2. Spatial embeddings are coordinate-based
  3. Spatial embeddings encode relevant external information
- A simple ratemaking model using spatial embeddings as input will inherit the desirable attributes

Spatial embeddings

Input to the encoder

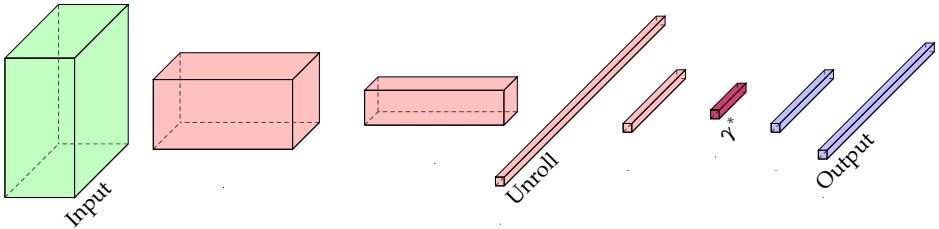
Input data = geographic data square cuboid





Spatial embedding construction

Encoder + decoder



Application on insurance data

We compare GAM (bivariate spline) with GLM (with spatial embeddings)

- Accident frequency prediction
- Home insurance in Québec
- Over 2 000 000 contracts

Poisson GAM:

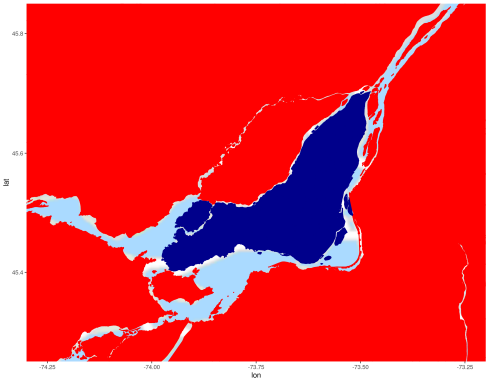
$$\ln(E[Y_i]) = \beta_0 + \ln \omega + \underbrace{\sum_{j=1}^{p} x_{ij}\alpha_j,}_{\text{traditional component}} + \underbrace{f_k(lon_i,\ lat_i)}_{\text{spline component}} + \underbrace{\sum_{j=1}^{\ell} \gamma^*_{ij}\beta_j,}_{\text{embedding component}}$$

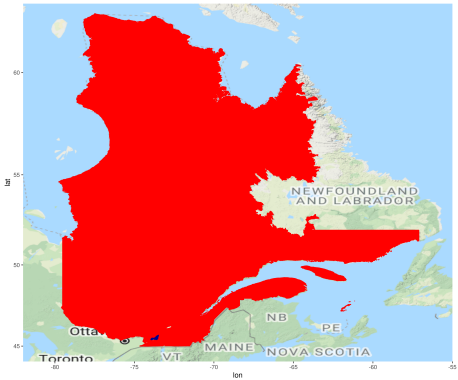
Test deviance in Québec

	Without embeddings		With embeddings	
k	Test	DoF	Test	DoF
0	–	–	**80663**	19
3	80766	7.18	80785	26.16
5	80767	18.63	80780	35.18
8	80837	43.97	80777	60.43
10	80771	64.89	80748	82.86
15	80853	126.60	80825	138.64
20	80852	181.65	80825	191.97

Spatial ratemaking

Out-of-sample prediction





- OOT : Out-of-territory + embeddings (red)
- GAM : Within territory + spatial splines (blue)
- C.P. : Center of population

C.P.	OOT	GAM	C.P.	OOT	GAM
Montréal	**14364**	14400	Sherbrooke	**2754**	2782
Québec	**3787**	3801	Saguenay	**958**	963
Laval	4046	**4043**	Levis	**2500**	2500
Gatineau	**6406**	6495	Trois Rivières	**2952**	2961
Longueuil	3203	**3185**	Terrebonne	**2656**	2677

Conclusion

Conclusion

- Easily incorporate spatial effects within predictive models
- Spatial embeddings improve (not replace) spatial models
- Other applications of spatial embeddings
  - in insurance: fraud detection, claims management, life insurance
  - in general: urban planning, crime prediction, election forecasting
- Arxiv paper: [Blier-Wong et al., 2021b]
- Thanks for your attention!
- `christopher.blier-wong.1@ulaval.ca`
- Icons from Freepik and fjstudio on `flaticon.com`

References I

Blier-Wong, C., Baillargeon, J.-T., Cossette, H., Lamontagne, L., and Marceau, E. (2020).
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