Quantification Under Class-Conditional Dataset Shift

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Counting Dogs and Bicycles

...when all the dogs are labradors and all the bikes are mountain bikes

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- NO CODE
- SOME EQUATIONS

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Data Scientist?

Supervised Classification

Supervised Classification

$$x \in \mathbb{R}^{(256x256x3)}$$

$$y \in \{dog, bicycle\}$$

Quantification

$$P(y = dog) = 0.6$$

$$P(y = bicycle) = 0.4$$

Isn't quantification trivial?

Still Trivial?

$$p'' = \frac{p' - fpr}{tpr - fpr}$$

- Forman's `Adjusted Count': 2008
- Rogen and Gladen: 1978
- Gart and Buck: 1960s

However…what if…?

Training Data

Test Data

Sample Selection Bias

However....what if....?

$$tpr(labradors) \neq tpr(dogs_{tr})$$

Sample Selection Bias

Three Possible Approaches

- Quantify the sub-classes separately: divide and conquer
- Weight the training data to match the test data
- Convert everything to a new feature representation

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Training Data

Test Data

Bikes

Dogs

Road Bikes

Town Bikes

Mountain Bikes

Σ

Labradors

Jack Russels

Beagles

Σ

Explicit Sub-Domains

Count by Main-class

Adjust by Main-class

Adjust by Main-class and Sub-domain

Bias vs. Variance

- Sub-domains reduce bias but increase variance

Sub-domains and size of dataset

Noise Problem

fpr 0.2

tpr 0.8

n= 10 100 1000

Noise Problem

$$p'' = \frac{p' - (fpr \pm \delta_{fpr})}{(tpr \pm \delta_{tpr}) - (fpr \pm \delta_{fpr})}$$

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Instance Weighting

- Training set

Instance Weighting

Instance Weighting

Kernel Mean Matching (KMM)

2007	2009
"Correcting Sample Selection Bias by Unlabeled data"	"Covariate Shift by Kernel Mean Matching"
Advances in Neural Information Processing Systems (NIPS)	Dataset Shift in Machine Learning
Huang	Gretton
Gretton	Smola
Borgwardt	Huang
Scholkopf	Schmittfull
Smola	Borgwardt
	Scholkopf
"KMM *always* improves test performance…"	"KMM…often makes performance slightly worse"

Instance Weighting

- 11% improvement
- All data for training classifier
- ‘Closest’ 50% for *tpr* and *fpr*

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mSDA

- Marginalised
- Stacked
- De-noising
- Autoencoders

De-Noising Autoencoders

Stacked De-noising Autoencoders (SDA)

Step 1: Train Autoencoders

Step 2: Train Classifier

VooDoo

SDA Feature Representation

Further Work?

- Adversarial Neural Networks
- Direct quantification with NNs
- Alternative distance measures

Take Aways

- At least do Foreman's AC for quantification
- Try mSDA for domain adaptation
- Consider biassing your test sets

Thank You!

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