Stanford University

CS 329P : Practical Machine Learning (2021 Fall)

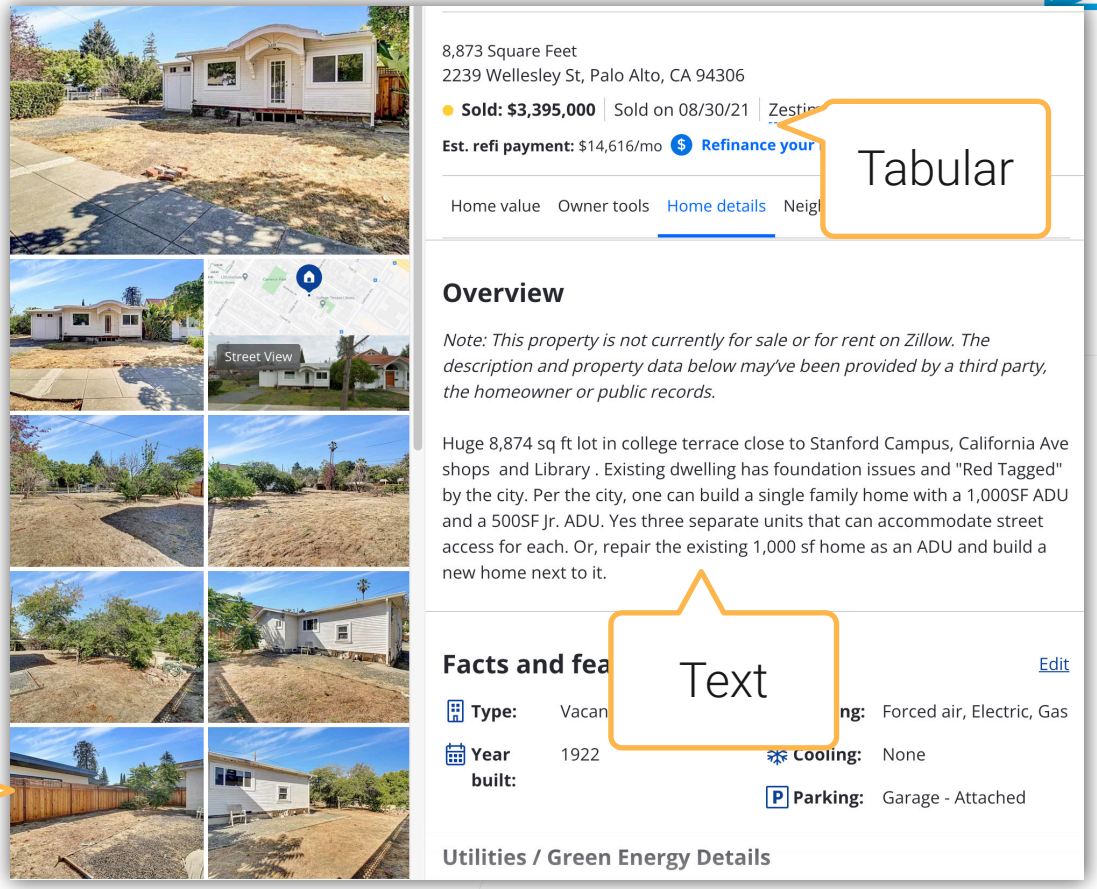
13.1 Multimodal Data

Qingqing Huang, Mu Li, Alex Smola

https://c.d2l.ai/stanford-cs329p

Multimodal Data

- Data is naturally multimodal in industry applications
  - The raw data contain tables, texts, images, audios, graphs, ...
- E.g. house sales

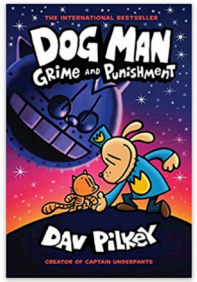


Amazon Product

Images + text + tabular

Graph

Text, images, videos



Dog Man: Grime and Punishment: A Graphic Novel (Dog Man #9): From the Creator of Captain Underpants (9) Hardcover – Illustrated, September 1, 2020

by Dav Pilkey (Author, Illustrator)

★★★★★ 36,089 ratings

#1 Best Seller in Children's Animal Comics & Graphic Novels

See all formats and editions

Hardcover
$6.48 prime

71 Used from $2.39
65 New from $3.45
3 Collectible from $3.99

Frequently bought together

Total price: $19.53

Add all three to Cart

- **This item:** Dog Man: Grime and Punishment: A Graphic Novel (Dog Man #9): From the Creator of Captain Underpant…
- Dog Man: Mothering Heights: A Graphic Novel (Dog Man #10): From the Creator of Captain Underpants (10) by Dav Pilkey
- Dog Man: For Whom the Ball Rolls: From the Creator of Captain Underpants (Dog Man #7) by Dav Pilkey Hardcover $6.43

B. A. Taylor

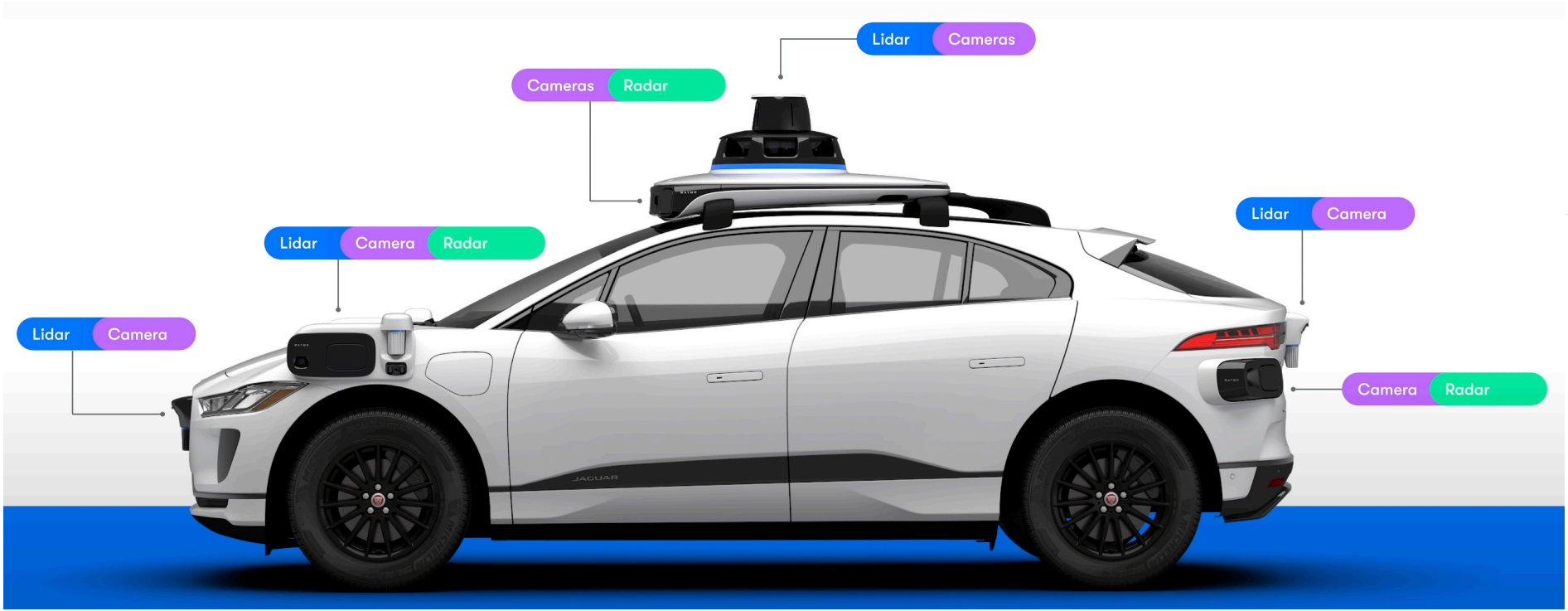
★★★★★ **Christmas present**

Reviewed in the United Kingdom on September 3, 2020

Verified Purchase

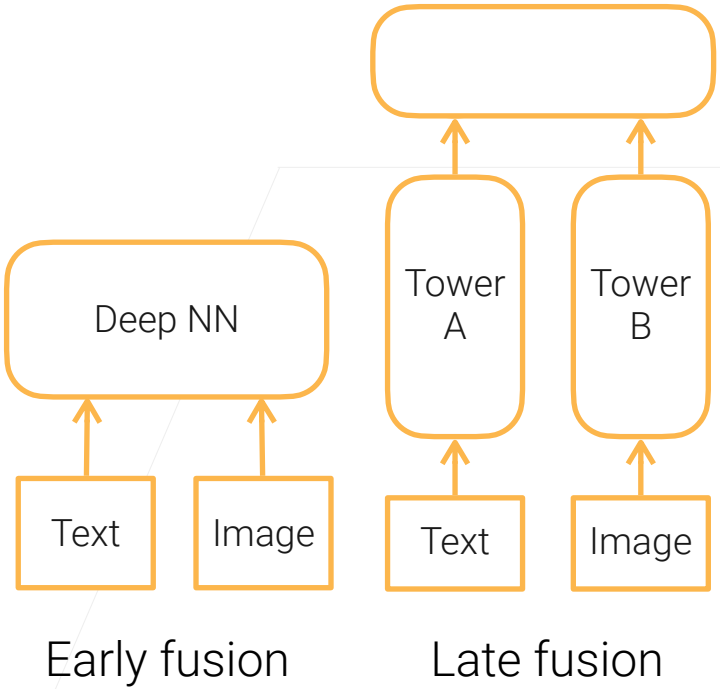
This is a Christmas present for my grandson, he loves the author, pity he has to wait another 4 months to read it.
Nice hard back book, with comic strip type stories.
I don't mind that it's in comic book format, just as long as he's enjoying reading.

Self-Driving Cars

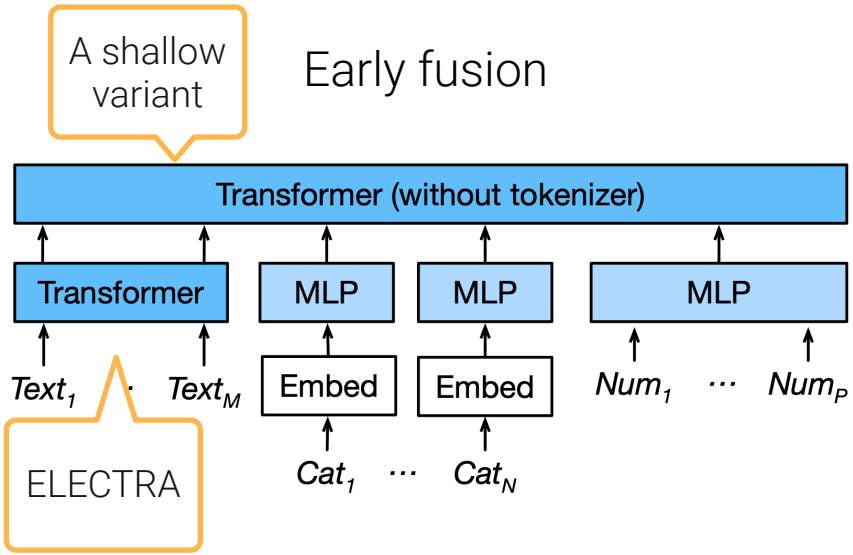


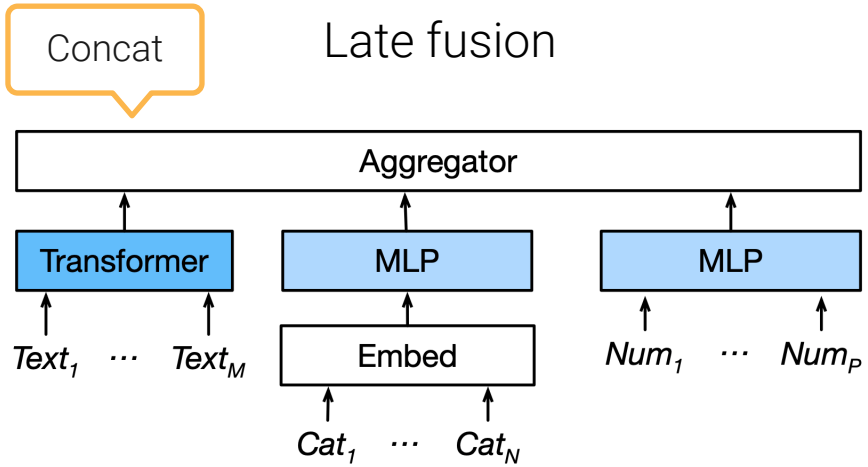
Multimodal Learning

- How to match different modal data into the same semantic space
  - Early vs late fusion
- How to construct loss
  - Combined to learn predict labels
  - Contrastive learning: embedding space in which similar sample pairs stay close to each other while dissimilar ones are far apart



Early vs Late fusion on Tabular + Text



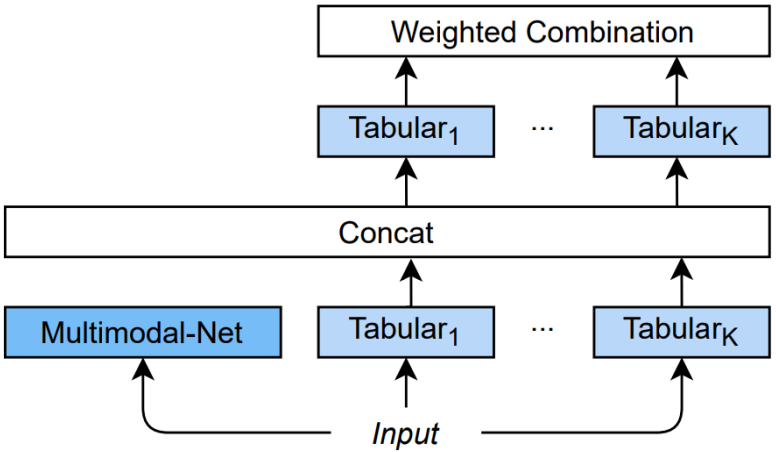


Shi et.al., NeurIPS'21

- Averaged scores on 13 datasets
  - Early fusion: 0.662, late fusion: **0.667** (the larger the better)

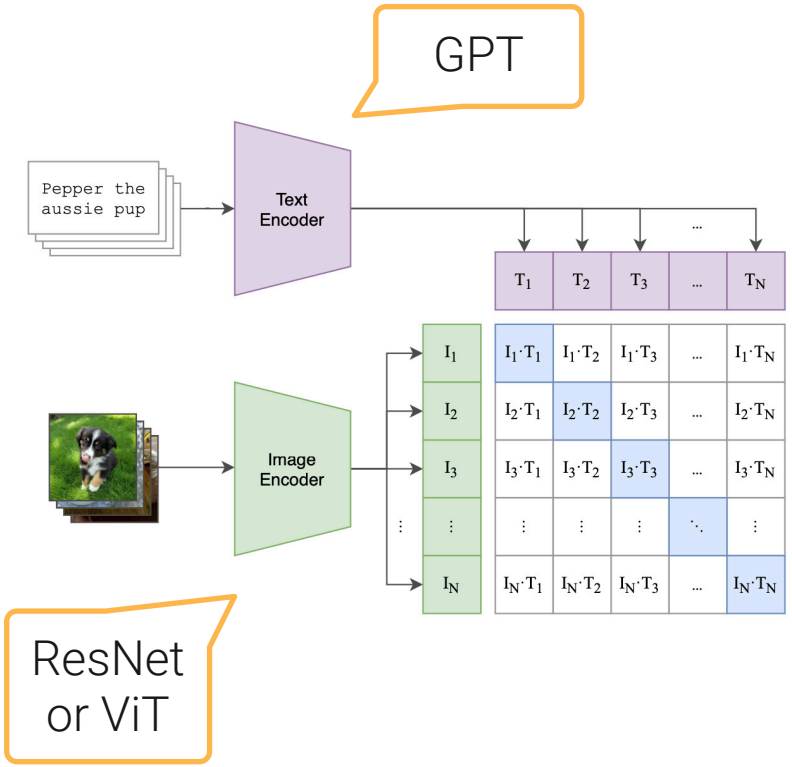
Model Ensemble

- Stack with other base models
- Averaged scores on 13 datasets
  - Multimodel-Net alone: 0.667
  - Stacked with Multimodel-Net: **0.683**
  - AutoGluon (N-gram for text): 0.659
  - H2O (Word2vec for text): 0.600



Shi et.al., NeurIPS'21

Image Representations from Text Supervision

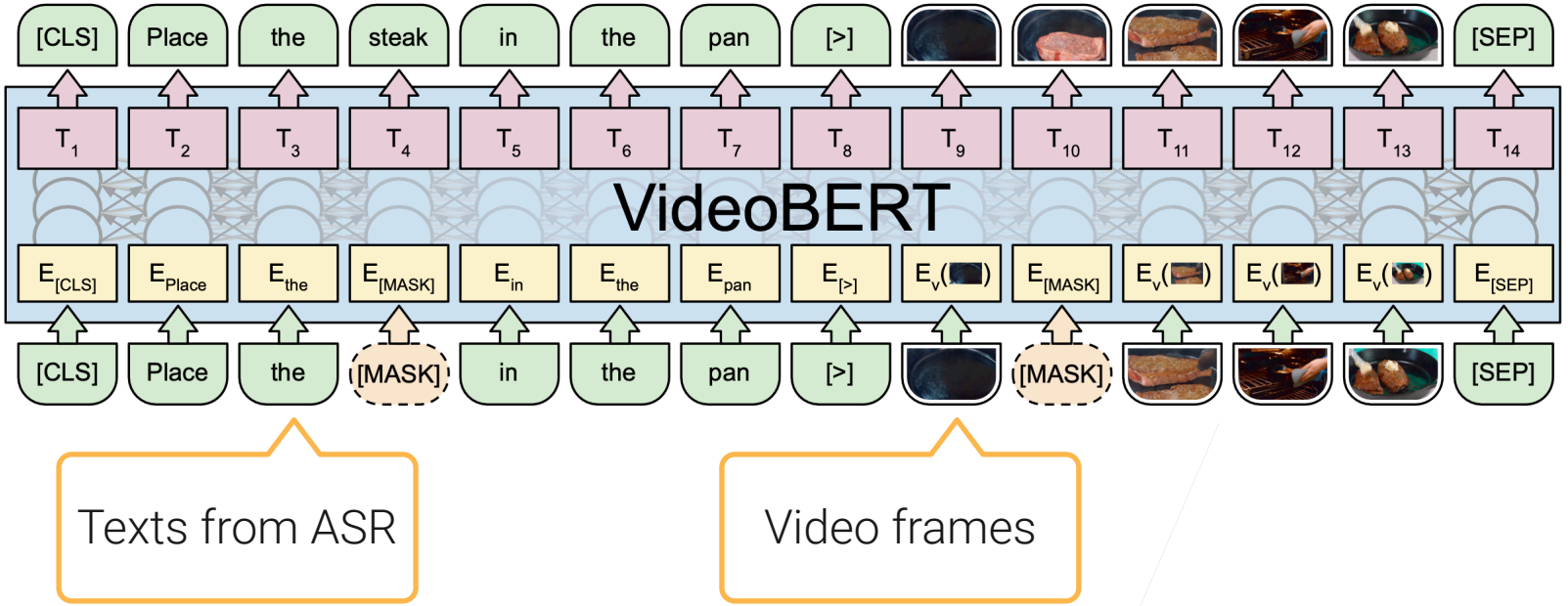



```
# extract feature representations of each modality
I_f = image_encoder(I) #[n, d_i]
T_f = text_encoder(T)  #[n, d_t]

# joint multimodal embedding [n, d_e]
I_e = l2_normalize(np.dot(I_f, W_i), axis=1)
T_e = l2_normalize(np.dot(T_f, W_t), axis=1)

# scaled pairwise cosine similarities [n, n]
logits = np.dot(I_e, T_e.T) * np.exp(t)

# symmetric loss function
labels = np.arange(n)
loss_i = cross_entropy_loss(logits, labels, axis=0)
loss_t = cross_entropy_loss(logits, labels, axis=1)
loss   = (loss_i + loss_t)/2
```

- Trained on 300M (image, text) pairs
- Comparative/better features compared to trained on ImageNet

CLIP. Radford et.al. ICML'21

VideoBERT: Video + Audio



[Sun et.al. ICCV'19]

- Trained on cooking/recipe 23K hours Youtube videos

Summary

- Real data is often multi-modal
- Project each modal data into a common space via early or late fusion
- Joint learning labels or contrastive learning for self-supervised training