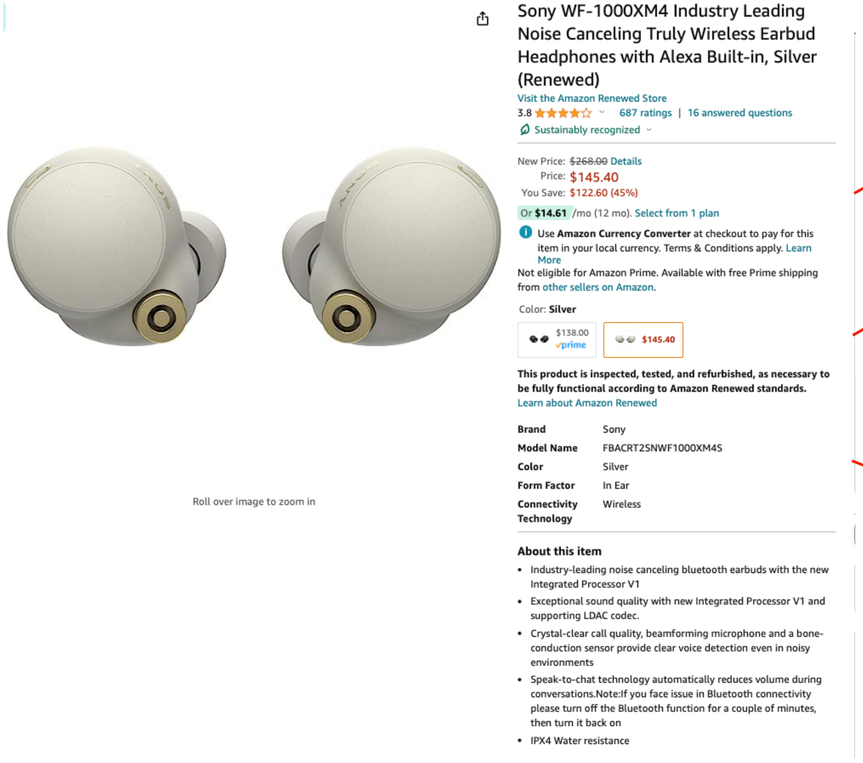


- Earbuds
- Headphone
- Computer
- Clothing
- Snacks
- …
- Personal Care

Product Advertising

Don’t Just Pay Attention, PLANT It

Transfer L2R Models to Fine-tune Attention in Extreme Multi-Label Text Classification

Debjyoti Saharoy, Javed Aslam

Khoury College of Computer Sciences, Northeastern University

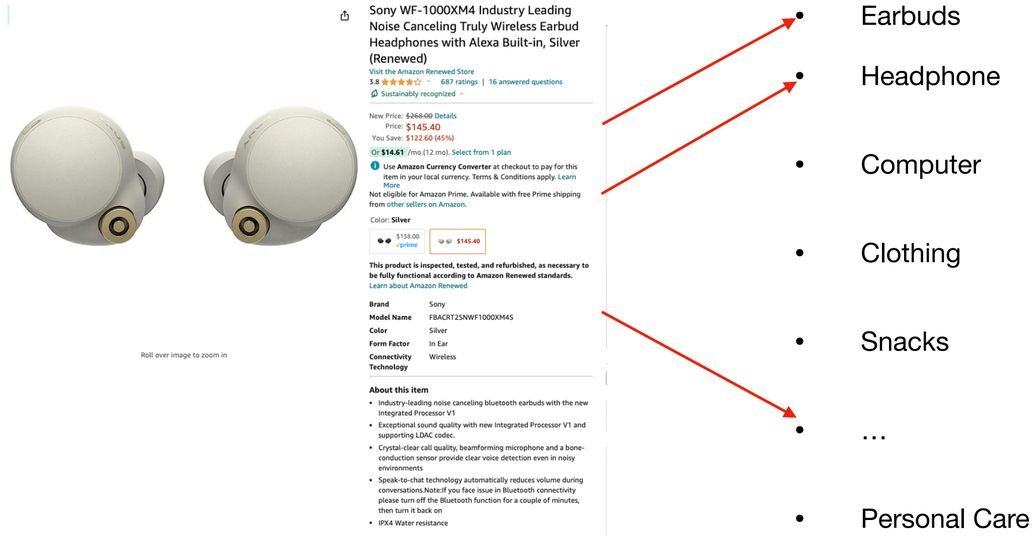
Outline

- Problem
- Shortcomings hitherto…
- Our Method
- Results and Improvements
- Conclusion

Problem: Extreme Multi-Label Text Classification (XMTC)

- Tagging a text with most relevant subset of labels from an extremely large -hundreds of thousands/millions, label set

Advertising



- Earbuds
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- …
- Personal Care

instance

label space

Healthcare (ICD)

Discharge Summary

History of Present Illness:
This is a 54-year-old gentleman with a history of deep venous thrombosis and pulmonary embolism in [**2155**], history of hypertension, and atrial fibrillation who presented to the Emergency Department with extreme dyspnea on exertion and weakness.
.....
Major Surgical or Invasive Procedure:
Attempt Repair of Ruptured Aortic Aneurysm
.....
Brief Hospital Course:
The patient was brought to the cardiac catheterization laboratory and a right heart catheterization revealed a pulmonary artery pressure of 49/17, right ventricular pressure
.....
PERTINENT RADIOLOGY/IMAGING:
Electrocardiogram revealed sinus tachycardia with a rate of 120. Intervals were otherwise normal. He had poor R wave progression. No ST changes.
.....
Discharge Diagnosis:
1. Pulmonary embolism; presenting as cardiogenic shock. 2. Atrial fibrillation/atrial flutter. 3. Renal insufficiency.
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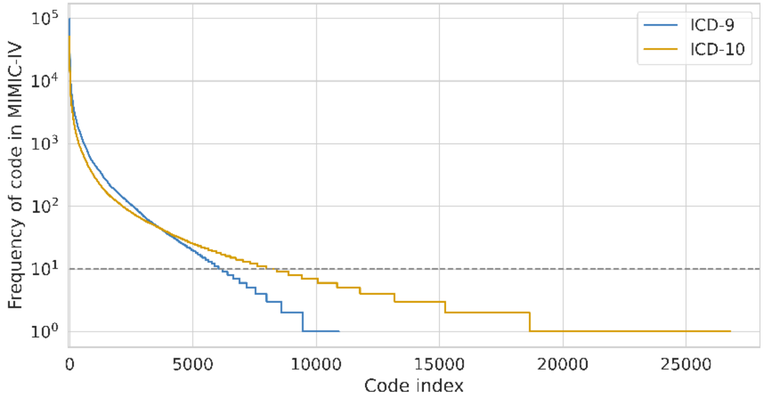
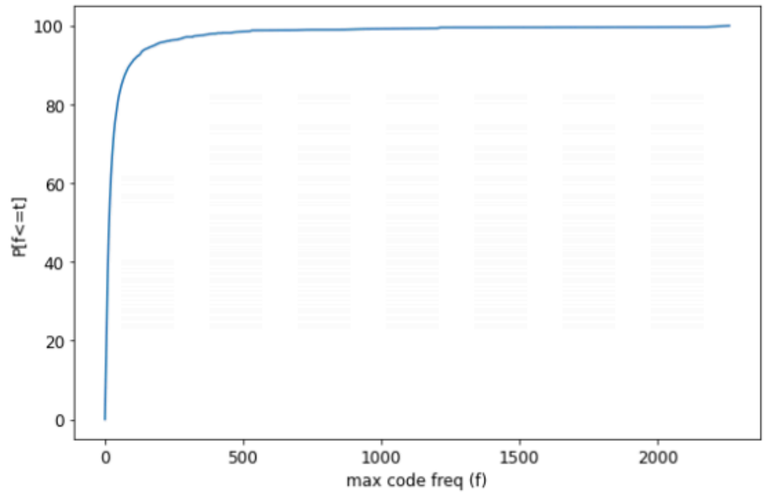
ICD Codes
37.21: Right Heart Cardiac Catheterization
38.7: Insertion of Intraluminal Device into Superior Vena Cava
88.52: Plain Radiography of Right Heart using High Osmolar Contrast
89.8: Autopsy
99.62: Restoration of Cardiac Rhythm

Problem: Main Challenge in XMTC

1. Datasets consists of texts with multiple lengthy narratives - However, only a small fraction of tokens are most informative with regard to assigning relevant codes
    - MIMIC-III/IV: more than 1500 tokens on average.
2. Code space is extremely high dimensional
    - 18000 and 170000 codes in ICD-9-CM and ICD-10-CM/PCS
3. Code distribution is heavily skewed
    - MIMIC-III: ~5411 out of 8929 codes appear < 10 times





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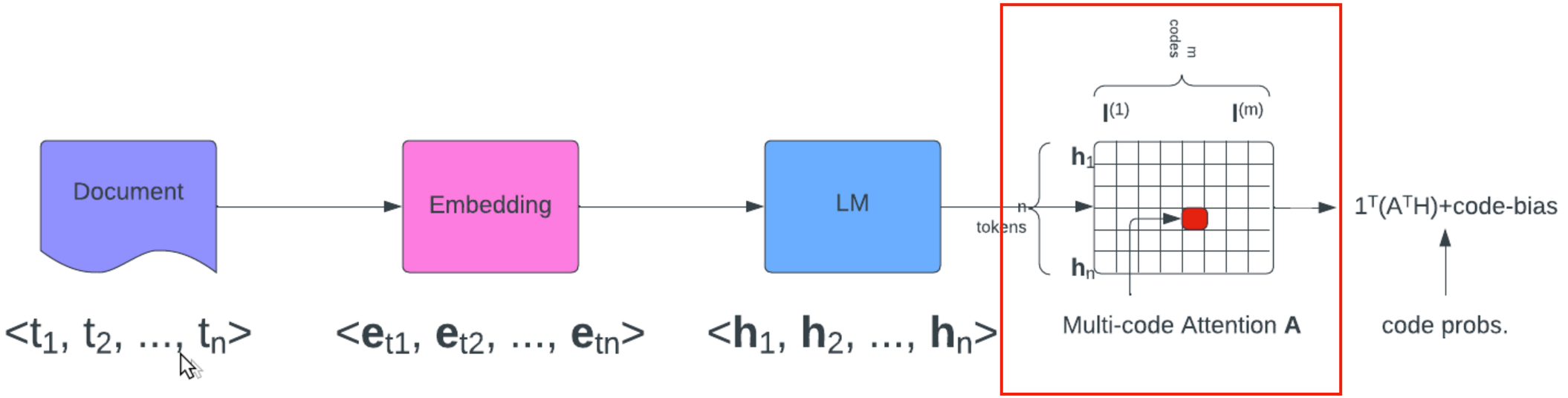
So far…

- *Attention* is crucial in any SOTA NLP model
  - Q/A[6], Translation[1,2,6], Summarization[3], Representation[4], Sentiment Analysis[5]
- Attention vital in XMTC

	AUC		F1				P@n	
Model	Macro	Micro	Macro	Micro	Diag	Proc	8	15
Scheurwegs et. al (2017)	–	–	–	–	0.428	0.555	–	–
Logistic Regression	0.561	0.937	0.011	0.272	0.242	0.398	0.542	0.411
CNN	0.806	0.969	0.042	0.419	0.402	0.491	0.581	0.443
Bi-GRU	0.822	0.971	0.038	0.417	0.393	0.514	0.585	0.445
CAML	0.895	**0.986***	**0.088**	**0.539***	**0.524***	**0.609***	**0.709***	**0.561***
DR-CAML	**0.897**	0.985	0.086	0.529	0.515	0.595	0.690	0.548

CAML (ACL ’18)[7]

So far…: Attention!!!



- Multi-code Attention: learns code specific attention to most informative tokens
- CAML (ACL ’18)[7], MSATT-KG (CIKM ’19)[8], MultiResCNN (AAAI ’20)[9], Hyper-Core (ACL ’20)[10], LAAT (IJCAI ’20)[11], ISD (ACL ’21)[12], Effective-CAN (EMNLP ’21)[13], MSMN (ACL ’22)[14], DiscNet (ACL ’22)[15], KEPTLongformer (EMNLP ’22)[16]
- Shortcoming: learning token relevance in relation to numerous codes results in lengthy training and overfitting.

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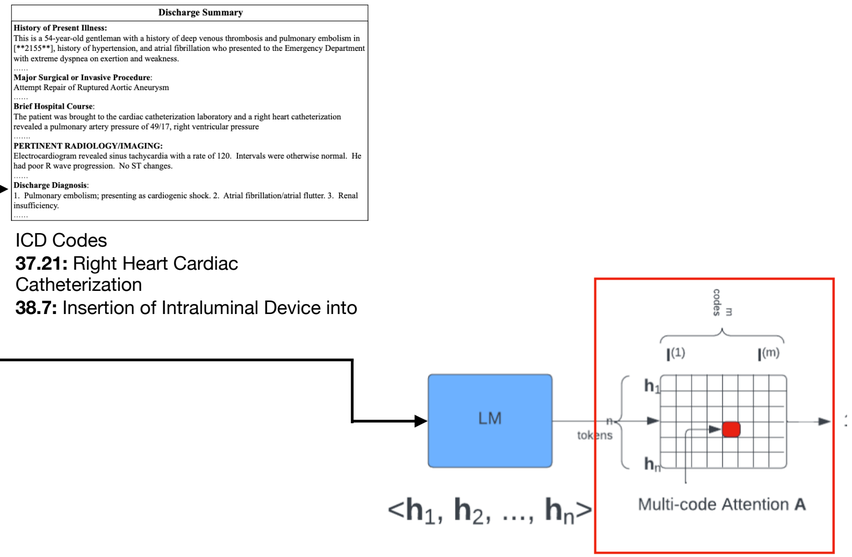
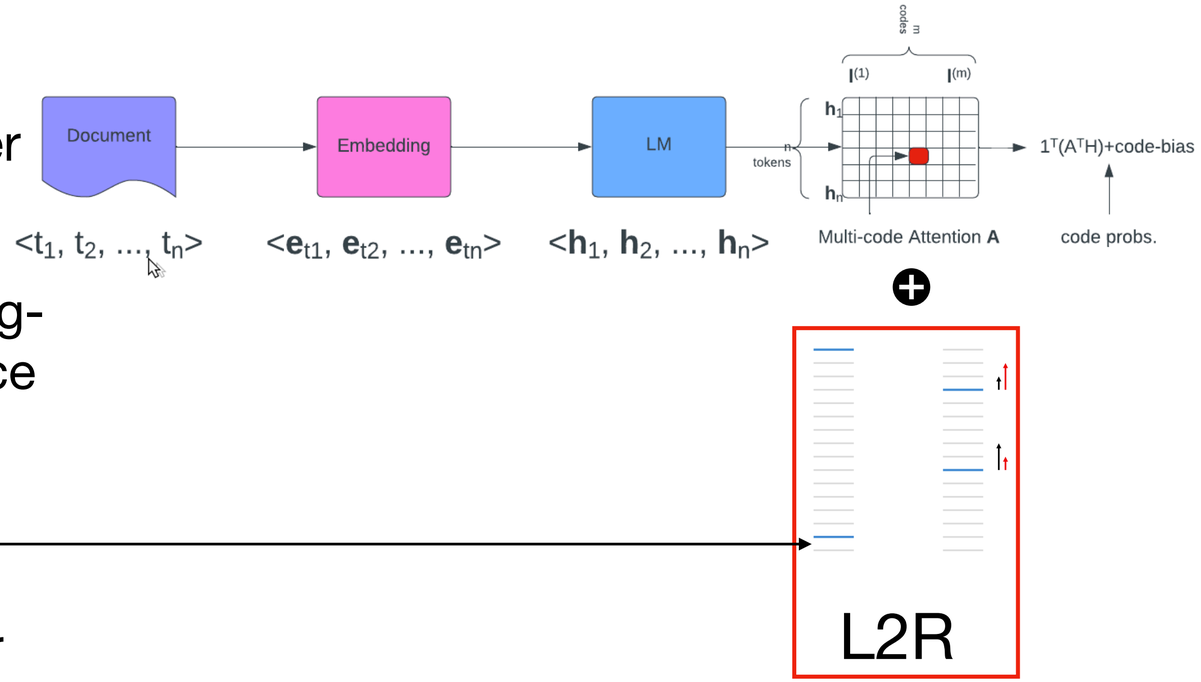


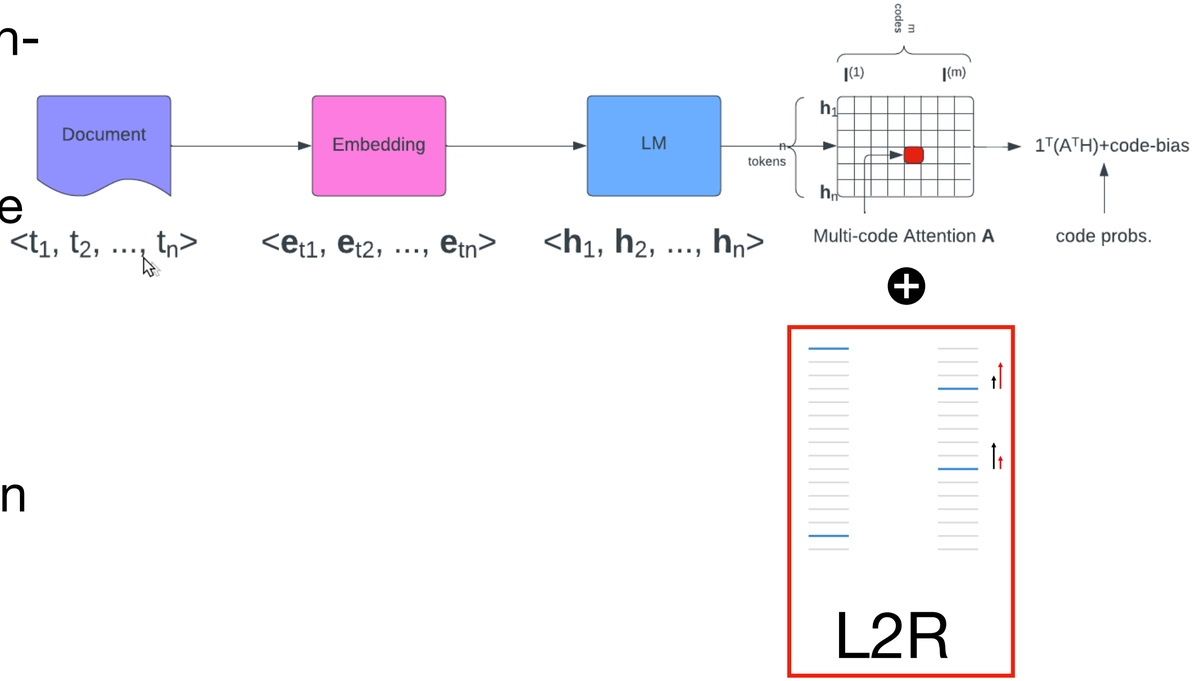
Our Method: PLANT

- **P**retrained & **L**everaged **A**tte**NT**ion: novel transfer learning to fine-tune attention in XMTC
- Capture token-code dynamics: pre-train Learning-to-Rank (L2R) model that ranks token significance by code relevance
- L2R activations as PLANTed attention
- Benefit: Start with well-informed attn wgts rather than random, then fine-tune



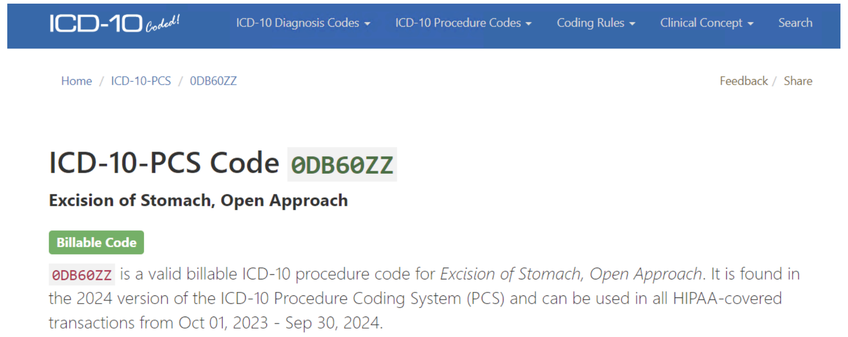
Our Method: PLANT

- **P**retrained & **L**everaged **A**tte**NT**ion: capture token-label dynamics with L2R model.
- Goal of L2R: Embed tokens to enhance relevance in sorting by taking dot products with label embeddings.
- Key step 1: Bootstrap “How much can I infer certain code from a token?”-> Mutual-Information Gain
- Key step 2: Max “How good is the code specific token list wrt top k tokens?” -> LambdaRank[17] /w nDCG@k



Our Method: Why PLANT works?

```
+ ('antecolic', 0.10208515)
+ ('blumgart', 0.07633876)
+ ('pancreatojejunostomy', 0.054873332)
+ ('gastrojejunostomy', 0.050927494)
+ ('fiducials', 0.05050926)
+ ('pancreaticojejunostomy', 0.04120218)
+ ('bloc', 0.039802585)
+ ('spirrometry', 0.038191367)
+ ('pancreaticoduodenectomy', 0.03692116)
+ ('splenoportal', 0.03632862)
+ ('gastrectomy', 0.03271102)
+ ('polya', 0.029407317)
+ ('modifier', 0.029353755)
+ ('hepaticojejunostomy', 0.028313298)
+ ('transgastric', 0.028199965)
+ ('duodenectomy', 0.023473764)
+ ('instruct', 0.023241024)
+ ('jejunostomy', 0.021264277)
+ ('gastrojejunal', 0.020096961)
+ ('resectable', 0.019506555)
```




```
+ ('antecolic', 117.187805)
+ ('pancreatojejunostomy', 116.8118)
+ ('blumgart', 105.97807)
+ ('undone', 103.58473)
+ ('splenoportal', 102.52783)
+ ('duodenectomy', 101.54767)
+ ('pancreaticoduodenectomy', 99.660324)
+ ('witzel', 99.13038)
+ ('adenomatosis', 98.637375)
+ ('spirrometry', 98.34472)
+ ('jejunostomy', 97.52427)
+ ('transgastric', 97.08511)
+ ('gastrojejunostomy', 97.03317)
+ ('pancreaticojejunostomy', 96.57304)
+ ('pancreatoduodenectomy', 95.53003)
+ ('jtube', 94.991776)
+ ('tubefeed', 93.88675)
+ ('cleard', 93.40699)
+ ('gastrogastric', 93.329994)
+ ('bloc', 92.97085)
+ ('esophagogastrectomy', 92.6966)
+ ('duodenojejunostomy', 92.550865)
+ ('fiducials', 92.35274)
+ ('trophic', 92.18849)
+ ('instruct', 92.13136)
+ ('efferent', 92.1006)
+ ('gastrojejunal', 91.979706)
+ ('basion', 91.517975)
+ ('hpb', 91.27107)
+ ('modifier', 90.64114)
+ ('enteroatmospheric', 90.56534)
+ ('gastrectomy', 90.19148)
+ ('ethylsuccinate', 90.10019)
+ ('dpca', 90.03682)
+ ('attaching', 90.016174)
+ ('periesophageal', 89.87409)
+ ('punctured', 89.7901)
+ ('malecot', 89.70523)
+ ('hepaticojejunostomy', 89.70446)
+ ('folloiwng', 89.670815)
```

- Key Step 1: Mutual-Info gain 👍
- Key Step 2: As goes L2R so goes XMTC 👍

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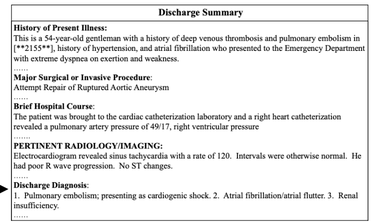

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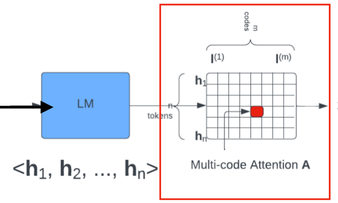
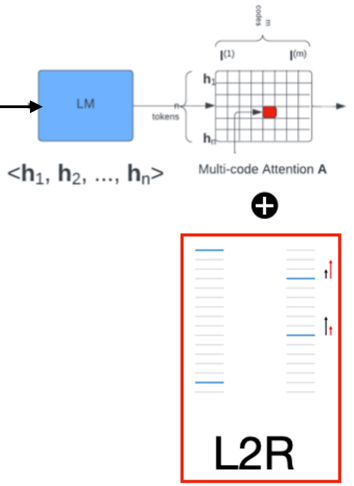




Results and Improvements: Metrics

- Precision: Out of all the items the model predicted as positive, how many were actually correct?
- Recall: Out of all the actual positive items, how many did the model correctly identify as positive?
- F1: balance conservatism (high precision but low recall) and liberalism (high recall but low precision)

Results: Improvements

Model	AUC		F1	
	Macro	Micro	Macro	Micro
MSMN	75.3	76.2	17.1	17.2
KEPTLongformer	82.7	83.3	30.4	32.6
PLANT (Ours)	**95.6***	**96.0***	**82.6***	**84.2***

MIMIC-III-rare50

Model	AUC		F1		P@k		
	Macro	Micro	Macro	Micro	P@5	P@8	P@15
CAML/DR-CAML	88.4	91.6	57.6	63.3	61.8	-	-
MSATT-KG	91.4	93.6	63.8	68.4	64.4	-	-
MultiResCNN	89.9	92.8	60.6	67.0	64.1	-	-
HyperCore	89.5	92.9	60.9	66.3	63.2	-	-
LAAT/JointLAAT	92.5	94.6	66.6	71.6	67.5	54.7	35.7
ISD	**93.5**	**94.9**	67.9	71.7	68.2	-	-
Effective-CAN	92.0	94.5	66.8	71.7	66.4	-	-
MSMN	92.8	94.7	68.3	72.5	**68.0**	-	-
PLANT (Ours)	93.1	**94.9**	**68.7**	**72.8**	67.2	**55.0***	**36.3***

MIMIC-III-top50

Model	AUC		F1		P@k		
	Macro	Micro	Macro	Micro	P@5	P@8	P@15
CAML/DR-CAML	89.7	98.6	8.8	53.9	-	70.9	56.1
MSATT-KG	91.0	99.2	9.0	55.3	-	72.8	58.1
MultiResCNN	91.0	98.6	8.5	55.2	-	73.4	58.4
HyperCore	93.0	98.9	9.0	55.1	-	72.2	57.9
LAAT/JointLAAT	92.1	98.8	10.7	57.5	81.3	73.8	59.1
ISD	93.8	99.0	11.9	55.9	-	74.5	-
Effective-CAN	92.1	98.9	10.6	58.9	-	75.8	60.6
MSMN	95.0	99.2	10.3	58.4	-	75.2	59.9
DiscNet	**95.6**	**99.3**	**14.0**	58.8	-	76.5	61.4
PLANT (Ours)	90.4	98.9	10.1	**59.4***	**84.0***	**77.1***	**61.7***

MIMIC-III-full

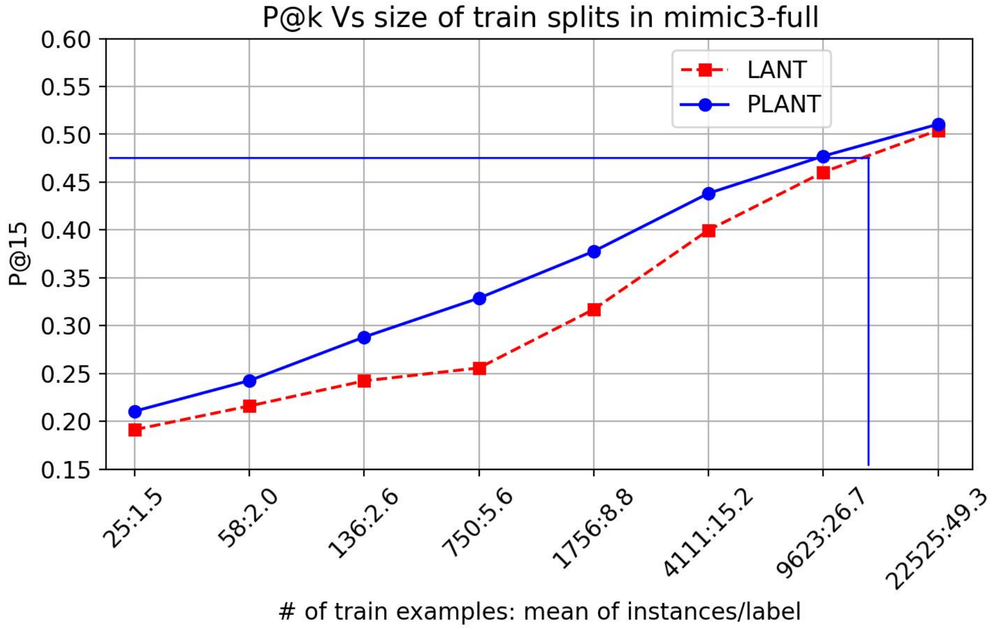
Model	AUC		F1		P@k		
	Macro	Micro	Macro	Micro	P@5	P@8	P@15
CAML/DR-CAML	91.1	98.5	16.0	55.4	-	66.8	52.2
MultiResCNN	94.5	**99.0**	21.1	56.9	-	67.8	53.5
LAAT/JointLAAT	**95.4**	**99.0**	20.3	57.9	-	68.9	54.3
PLANT (Ours)	94.8	**99.0**	19.6	57.1	**78.1***	**70.6***	**55.6***

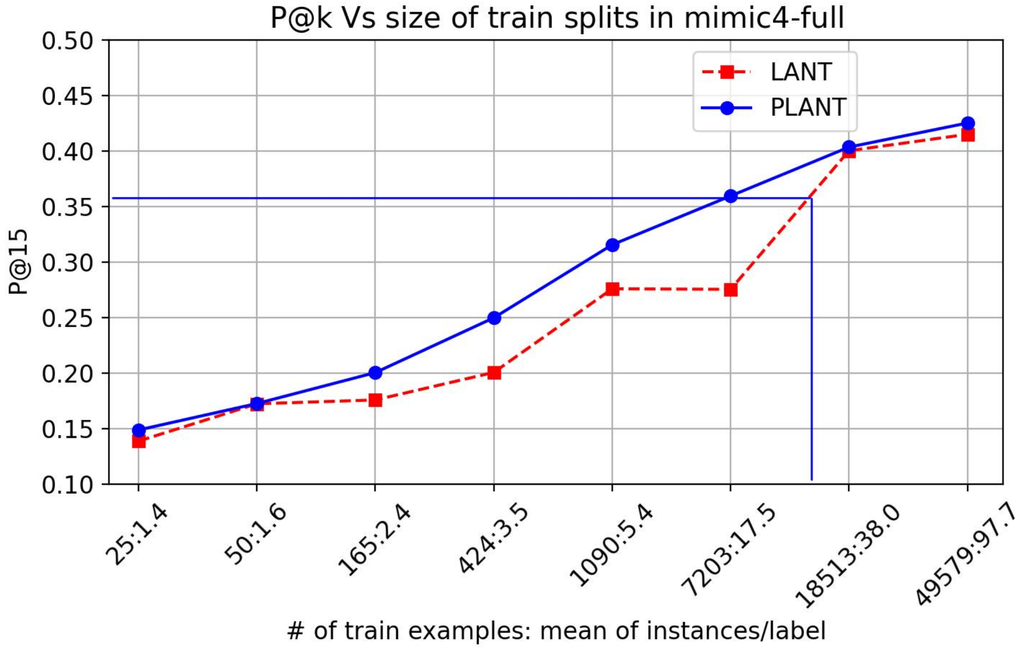
MIMIC4-IV-full

- *Precision:* Out of all the items the model predicted as positive, how many were actually correct?
- *Recall:* Out of all the actual positive items, how many did the model correctly identify as positive?
- *F1:* balance conservatism (high precision but low recall) and liberalism (high recall but low precision)

* indicates that the performance difference between PLANT and the next best is significant (, using the Approximate Randomization test).

Results: Juice is worth the squeeze!





P@15 for PLANT vs LANT (Learned Attention) with different # of training examples on MIMIC-III-full and MIMIC-IV-full.

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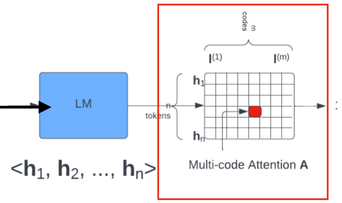

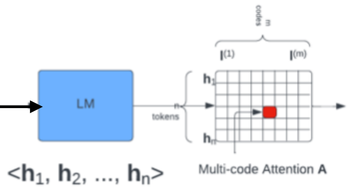

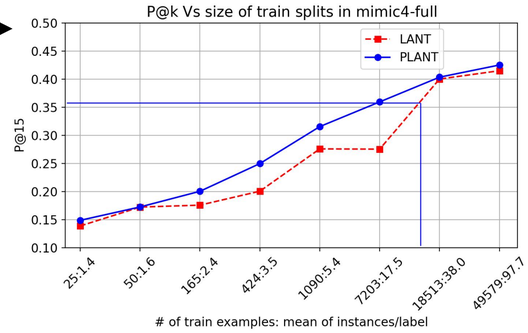

Conclusion

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