Enhancing Risk Aware Decision in Healthcare with Uncertainty Quantification

Rahul Vishwakarma, Jinha Hwang, Benyamin Ahmadnia
California State University Long Beach

Motivation: Unreliable point prediction

x Medica Text Transcription Data

$f(x) \rightarrow y$

y Point Prediction Lack of Trust

- Most of the Machine Learning model lacks **calibration**.
- **No guarantee** for uncertainty estimations for new data.

Prior Work

- **Confidence intervals**: Not be well-suited for complex data and model.
- **Bayesian Inference:** Require careful selection of prior distributions.
- **Bootstrap:** Computationally expensive.

Method: Set valued prediction

- **Idea**: Instead of calibrating the probabilities for each individual outcome (e.g., Y = 1), apply calibrated probabilities to a set of potential outcomes (e.g., Y ∈ {1, 2, 3}).
- **Goal**: Forecast a limited collection of reasonable responses.
- **Benefit**: Model Agnostic.

Conformal Prediction

Medical Transcription

SUBJECTIVE:, This 23-year-old white female presents with complaint of allergies. She used to have ...

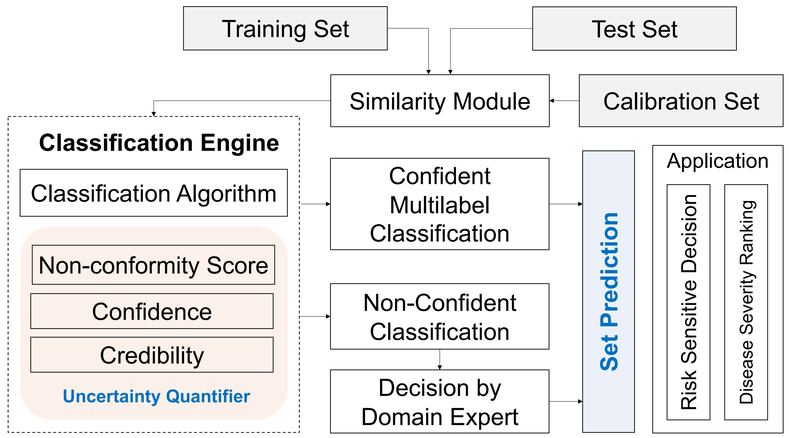
→ Gastroenterology / Neurology / Surgery

For at least one of these answers to be correct with guaranteed probability

$$\wp(Y \in \mathbb{C}(X)) \geq 1 - \epsilon$$

$Significance\ Level = 0.75 \rightarrow \Gamma^{0.25} = \{"Gastro", "Neurology", "Surgery"\}$

Proposed Solution



Experiment

Data: MTSamples Medical Transcription

Clinical Labels: {0} Cardiovascular/Pulmonary, {1} Consult History and Phy, {2} Gastroenterology, {3} General Medicine, {4} Neurology, {5} Obstetrics/ Gynecology, {6} Surgery, {7} Others

Multinomial Naive Bayes

	0	1	2	3	4	5	6	7
0	57	0	1	1	0	0	1	3
1	0	28	2	0	0	0	0	2
2	32	7	404	22	18	17	30	15
3	0	0	0	34	0	0	2	0
4	0	0	2	0	32	0	0	1
5	1	1	5	0	0	29	2	0
6	0	0	0	1	0	0	21	0
7	0	1	3	0	0	0	0	12

Conformal Inference

	0	1	2	3	4	5	6	7
0	8	2	34	5	4	1	4	5
1	3	2	20	0	1	5	0	1
2	68	34	290	39	27	33	17	37
3	4	4	17	3	1	3	1	3
4	2	5	19	4	1	1	1	2
5	5	0	23	3	0	3	0	4
6	2	2	10	2	0	0	3	3
7	2	0	11	1	1	0	0	1

Inference: *p*-values

p-values								$y\ (sig = 0.20)$
p-0	*p-1*	*p-2*	*p-3*	*p-4*	*p-5*	*p-6*	*p-7*	
0.125	0.122	0.131	0.373	0.122	0.122	0.130	0.124	3
False	False	False	**True**	False	False	False	False	

Performance Metrics

sig	*mean_err*	*avg_c*
0.5	0.506	0.604
0.7	0.701	0.371
0.8	0.804	0.251
0.9	0.894	0.115

- Coverage: proportion of true target values that fall within the pred intervals.
- Efficiency: how tight the prediction intervals are.

Reject Predictions: *null set*

sig	*conf*	*prediction*
0.5	0.61	{NULL}
0.15	0.86	{*surgery*}
0.10	0.87	{*surgery, others*}

Algorithm agnostic method for "***reject***" – model cannot provide a confident prediction for this input.

Disease Severity Ranking

$Confidence\ (x) = \sup\{1 - \epsilon : |\Gamma_\epsilon(x)| \leq 1\}$ Derive the confidence of each predicted label.

$c(label_1) >, \ldots, c(label_n)$ Rank the instances of same label based on the confidence score.

Conclusion

- Reject option (null set) for more trustworthy model.
- NCM based on Lesk Score for conformal prediction.
- Refine classification decisions based on ranking.

LONG BEACH STATE UNIVERSITY
College of Engineering

CRYSTALYTIC

KDD2023 AUGUST 6-10
29TH ACM SIGKDD CONFERENCE ON KNOWLEDGE DISCOVERY & DATA MINING