Machine Learning and Human Classification to Identify Peripherally Inserted Central Catheter (PICC) Tip Position from Radiology Reports

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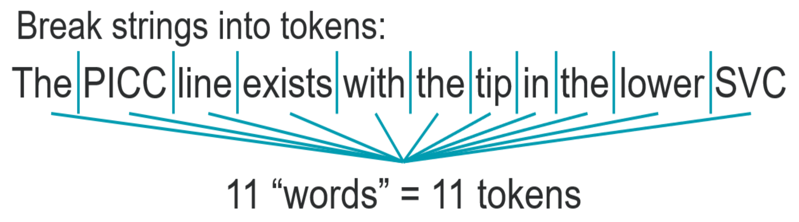
Introduction

- Infants in the neonatal intensive care unit (NICU) frequently need peripherally inserted central catheters (PICC) to provide medications, parenteral nutrition, and fluids.
- An upper extremity PICC tip is optimally positioned "centrally" in the superior vena cava (SVC) or at the SVC-right atrial (RA) junction.
- Malpositioned PICC lines run the risk of extravasation into surrounding spaces or causing vascular damage.
- PICC tip position must be confirmed frequently, as the tip may move from its original position, especially in neonates.
- With advancements in technology and the use of electronic health records, there has been a growing interest in utilizing automation to assist in mitigating medical errors.
- This research seeks to use natural language processing and supervised machine learning to train and test various algorithms based primarily on text analysis of radiology reports from infants with an upper extremity PICC.

<u>Steps of Natural Language Processing (NLP)</u>

Feature Extraction



Feature Processing

Implement machine learning algorithms to process and "learn" from the features

Performance Evaluation

Test model to evaluate how well it is able to achieve its goal with new cases

Methods

- **17,596** radiology reports met inclusion criteria.

Human Classification / Training Set Generation

- Two individuals manually classified the PICC tip position in radiograph reports as one of twelve anatomical locations.
- A two category Boolean classification was also used, with the Boolean Appropriate position defined as a tip in the SVC or SVC/RA.
- A board-certified radiologist made the final determination for classifications not consistent between the raters.

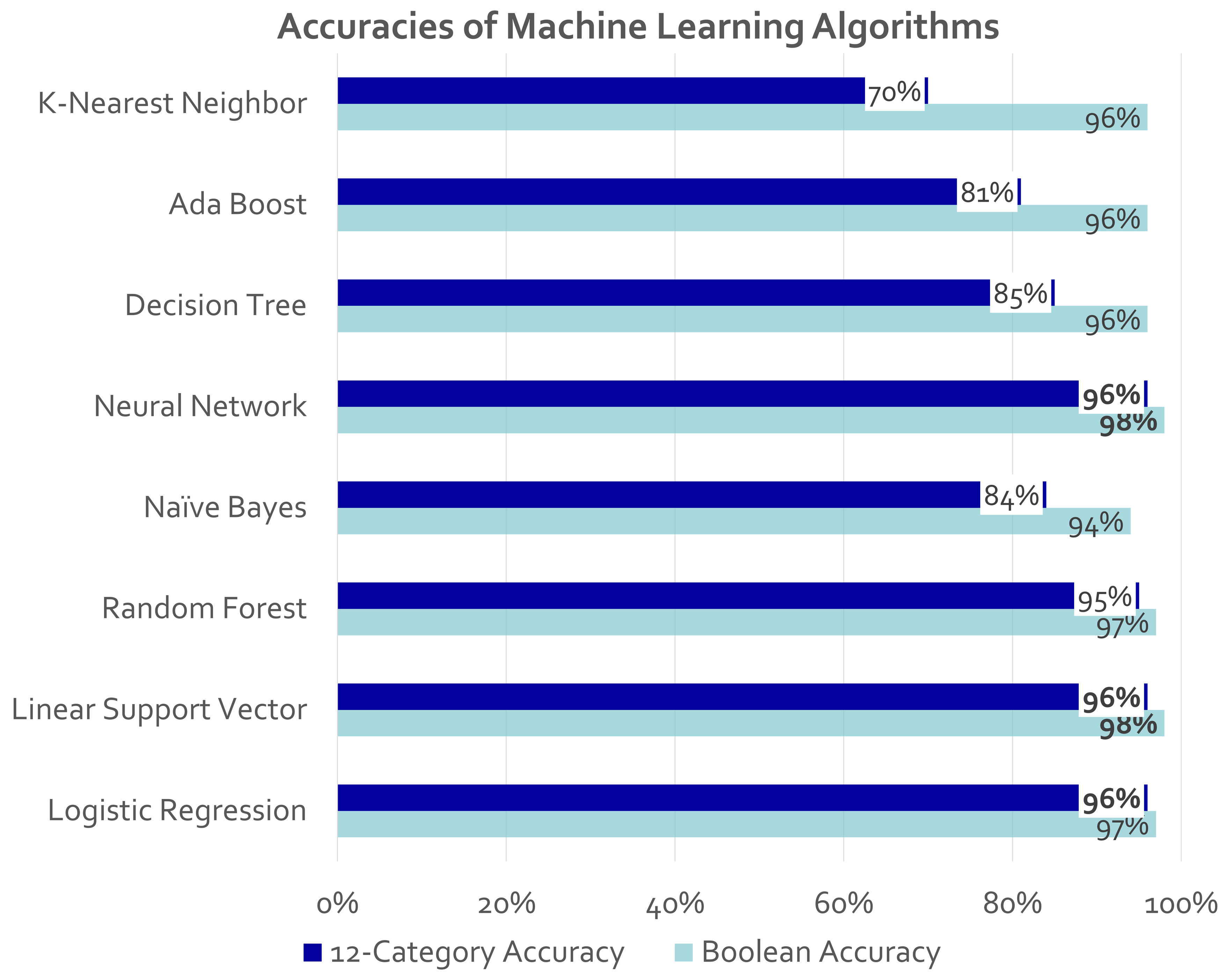
Natural Language Processing / Model Creation

- To help limit bias due to disproportionate category numbers, a 70/30 training/testing split of data was performed in each of the 12 categories.
- Build and test models using several machine learning algorithms. Analysis was conducted through the scikit-learn library in python.

Human Classification of Radiograph Reports

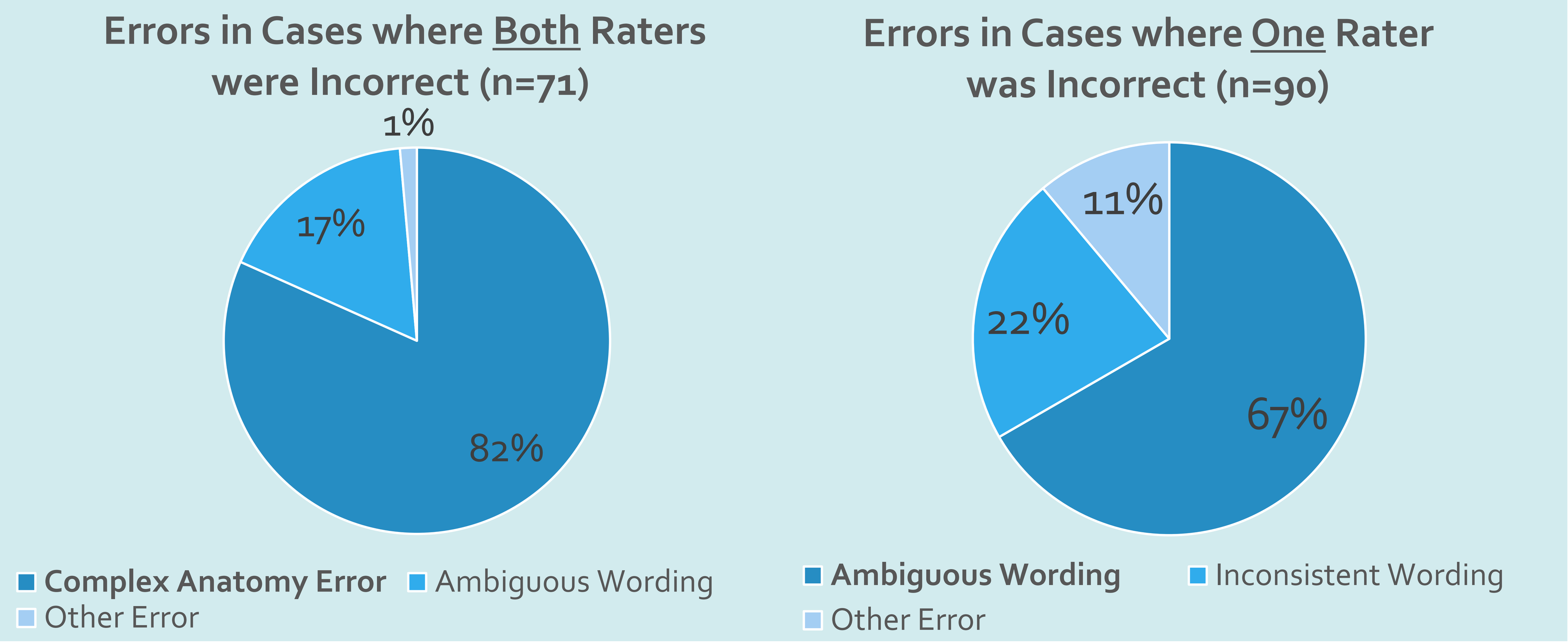
Anatomical Location	# of Reports	Boolean Class
Cephalic	11	Non-Central
Axillary	360	Non-Central
Axillary/Subclavian	62	Non-Central
Subclavian	943	Non-Central
Subclavian/Brachiocephalic	116	Non-Central
Brachiocephalic	2811	Non-Central
Brachiocephalic/SVC	540	Non-Central
Neck	430	Non-Central
Right Atrium	1520	Non-Central
Other	143	Non-Central
SVC	9750	Central
SVC/Right Atrium	910	Central

Results



- The confidence intervals range from +/- 0.8% for K-Nearest Neighbor 12 category accuracy to +/- 0.25% for NN and LSV Boolean accuracy

Interrater Analysis



- Cohen's Kappa score for interrater reliability was 0.98.
- 161 (0.91%) reports were classified differently between the 2 raters

Discussion/Conclusions

- Resulting algorithms yielded 12 category (up to 96%) and Boolean (up to 98%) accuracies that rival the accuracy of human classifiers
- Machine learning models can automatically extract the anatomical location of PICC tips from radiology reports
- Rare but important patterns of disagreements in human classification are present, stemming mainly from ambiguously worded radiology reports and systemic classification errors

Future Directions

- Implement automated malpositioned PICC notifications through a PICC Board, daily emails, and/or analysis of progress notes
- Apply machine learning algorithms to extract PICC location from <u>radiograph images</u>, using radiology report classifications as labels

References

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