Identifying Significance of Discrepancies in Radiology Reports

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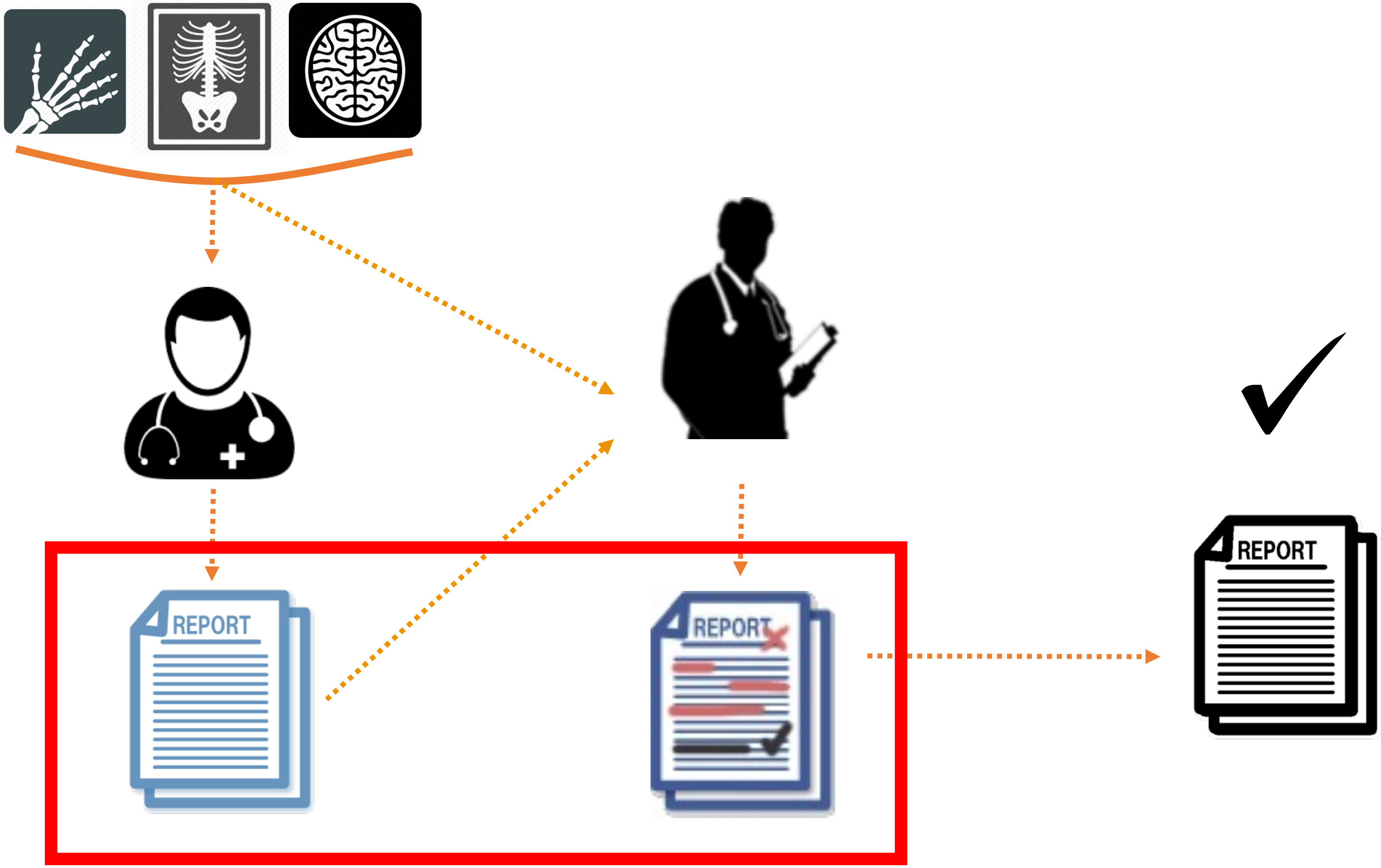
MedStar Health Research Institute

MedStar Georgetown University Hospital

Outline

- Motivation
- Framework
- Evaluation
- Conclusions

Overview of Clinical Workflow

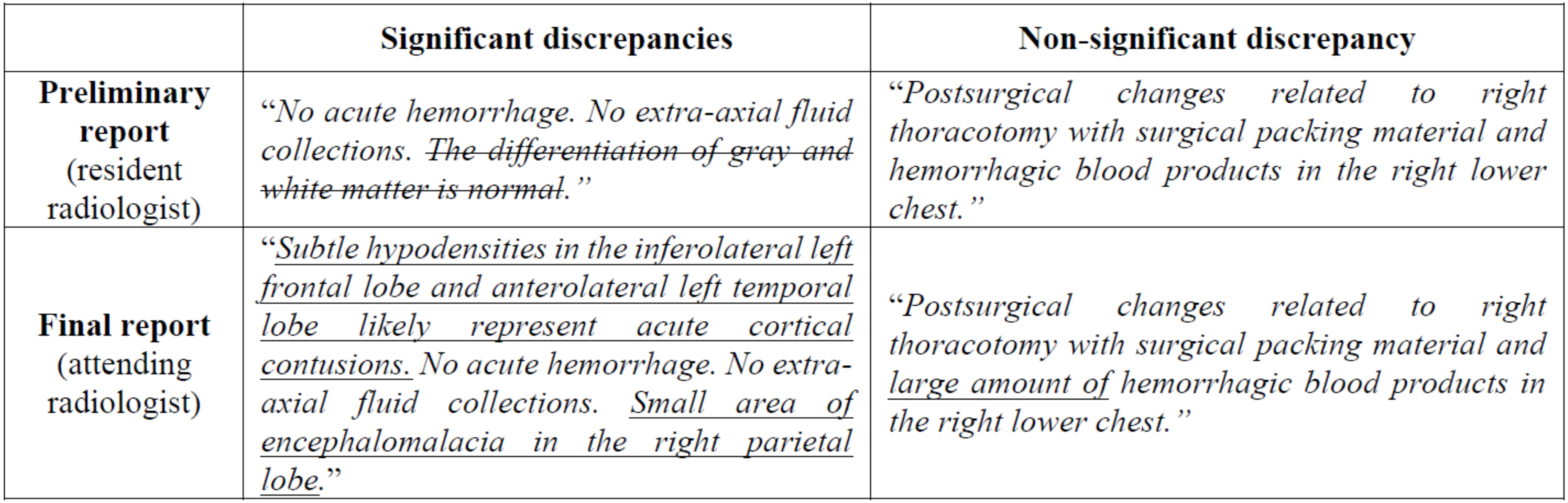


Example

Initial Report	Final Report
No acute hemorrhage. No extra-axial fluid collections. ~~The differentiation of gray and white matter is normal~~.	"Subtle hypodensities in the inferolateral left frontal lobe and anterolateral left temporal lobe likely represent acute cortical contusions. No acute hemorrhage. No extra-axial fluid collections. Small area of encephalomalacia in the right parietal lobe."

Introduction

- Two types of discrepancies



	Significant discrepancies	Non-significant discrepancy
Preliminary report (resident radiologist)	*"No acute hemorrhage. No extra-axial fluid collections. ~~The differentiation of gray and white matter is normal~~."*	*"Postsurgical changes related to right thoracotomy with surgical packing material and hemorrhagic blood products in the right lower chest."*
Final report (attending radiologist)	*"Subtle hypodensities in the inferolateral left frontal lobe and anterolateral left temporal lobe likely represent acute cortical contusions. No acute hemorrhage. No extra-axial fluid collections. Small area of encephalomalacia in the right parietal lobe."*	*"Postsurgical changes related to right thoracotomy with surgical packing material and large amount of hemorrhagic blood products in the right lower chest."*

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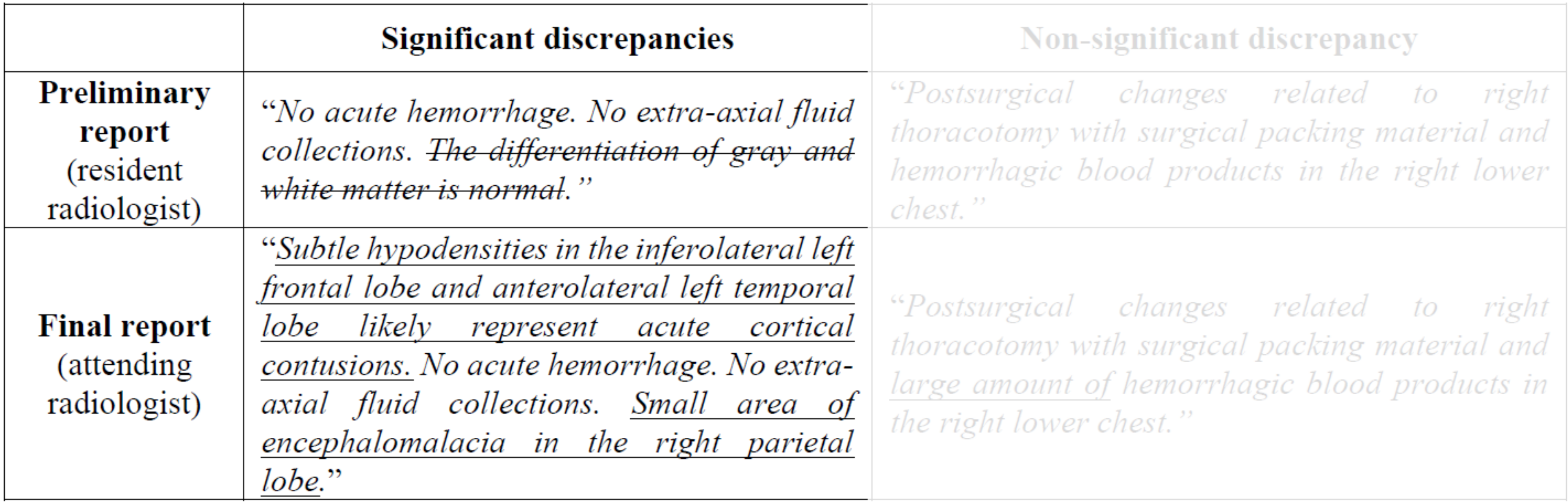

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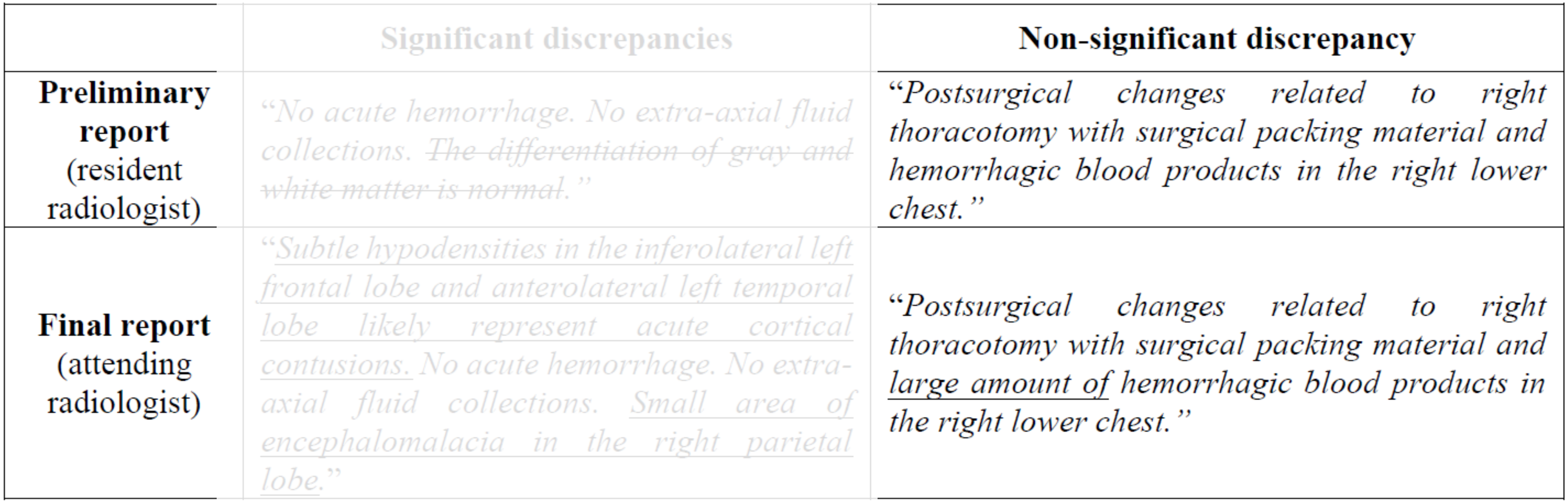

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Problem

- Significant discrepancies are important
  - In the patient care and resident's education
- Manual surveillance is difficult
- Previous work: Using wording differences (Kalaria, et al. 2015)
  - Not-accurate: Many wordings are due to style changes and do not reflect misinterpretations or misdiagnoses

This work

We propose a framework for accurate identification of significant reports

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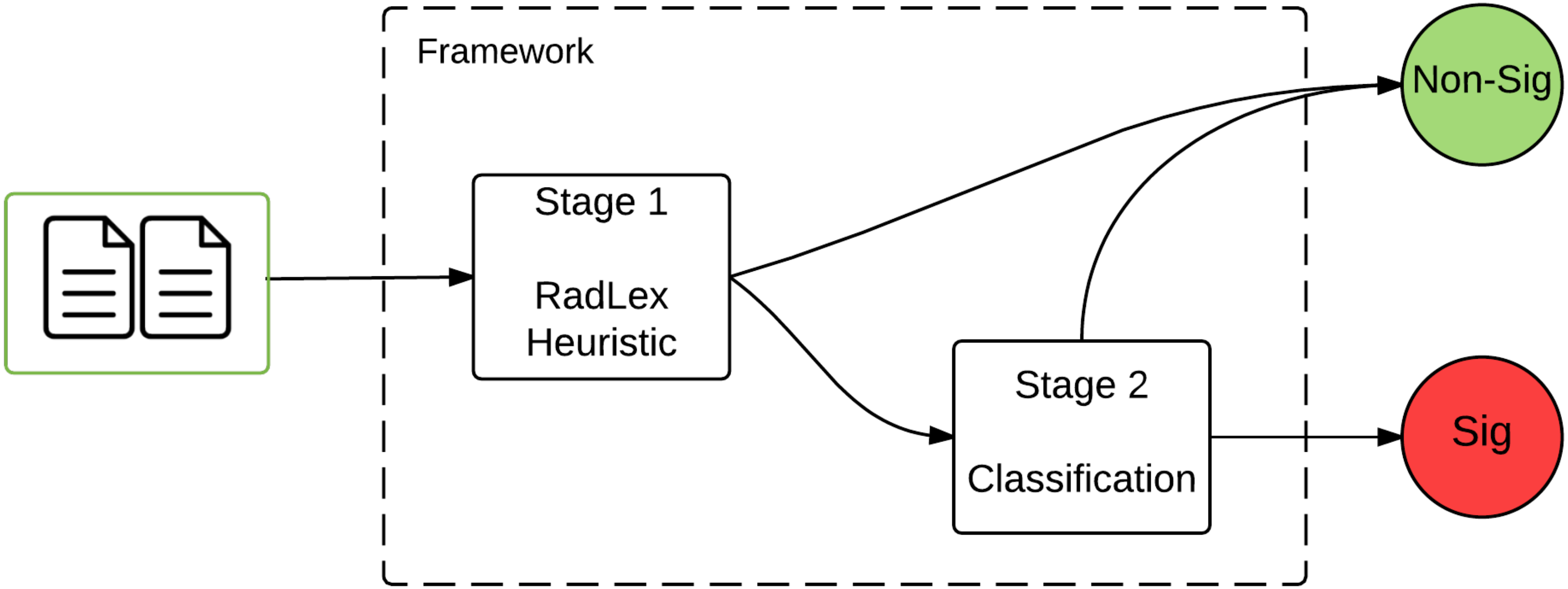
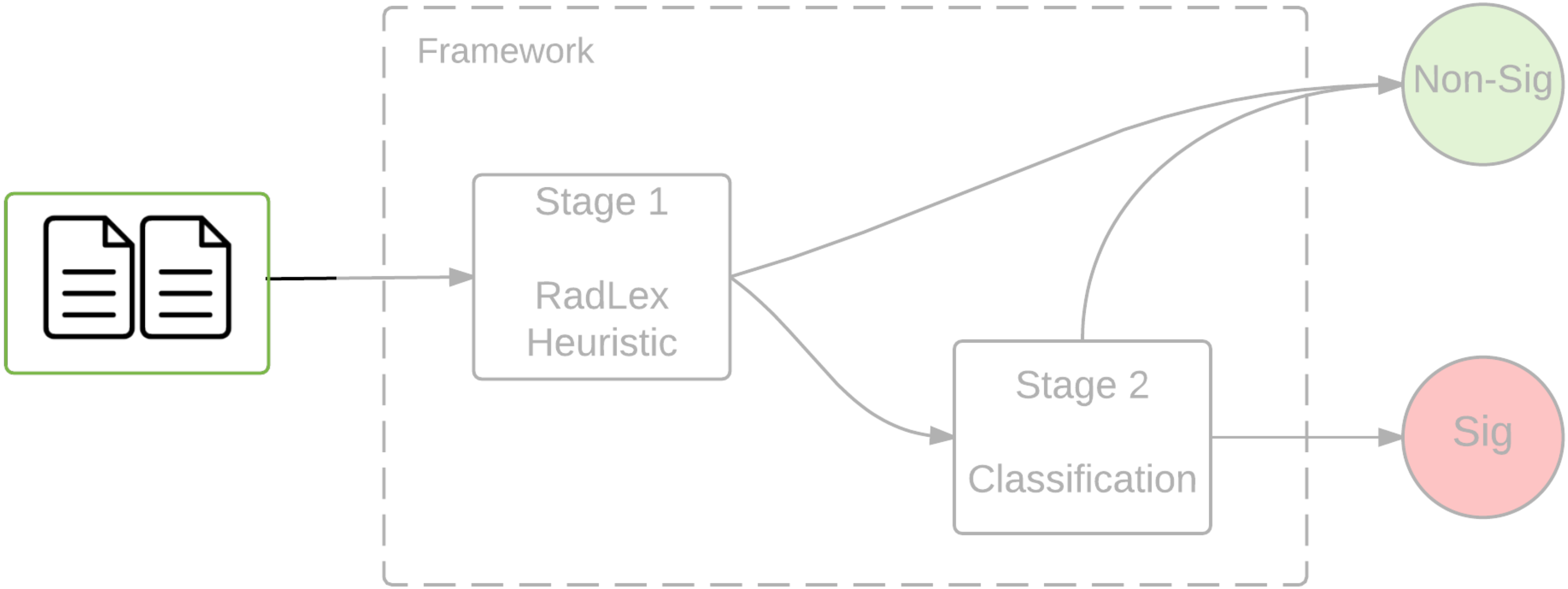
Data

- Collection of annotated radiology reports with discrepancies obtained from a large urban hospital for evaluation.
  - Set of 350 reports
- Two sections for each report:
  - Findings: contains the full interpretation of the radiology examination
  - Impression: highlights important aspects of the report.

Overview


Framework
Stage 1
RadLex Heuristic
Stage 2
Classification
Non-Sig
Sig

Overview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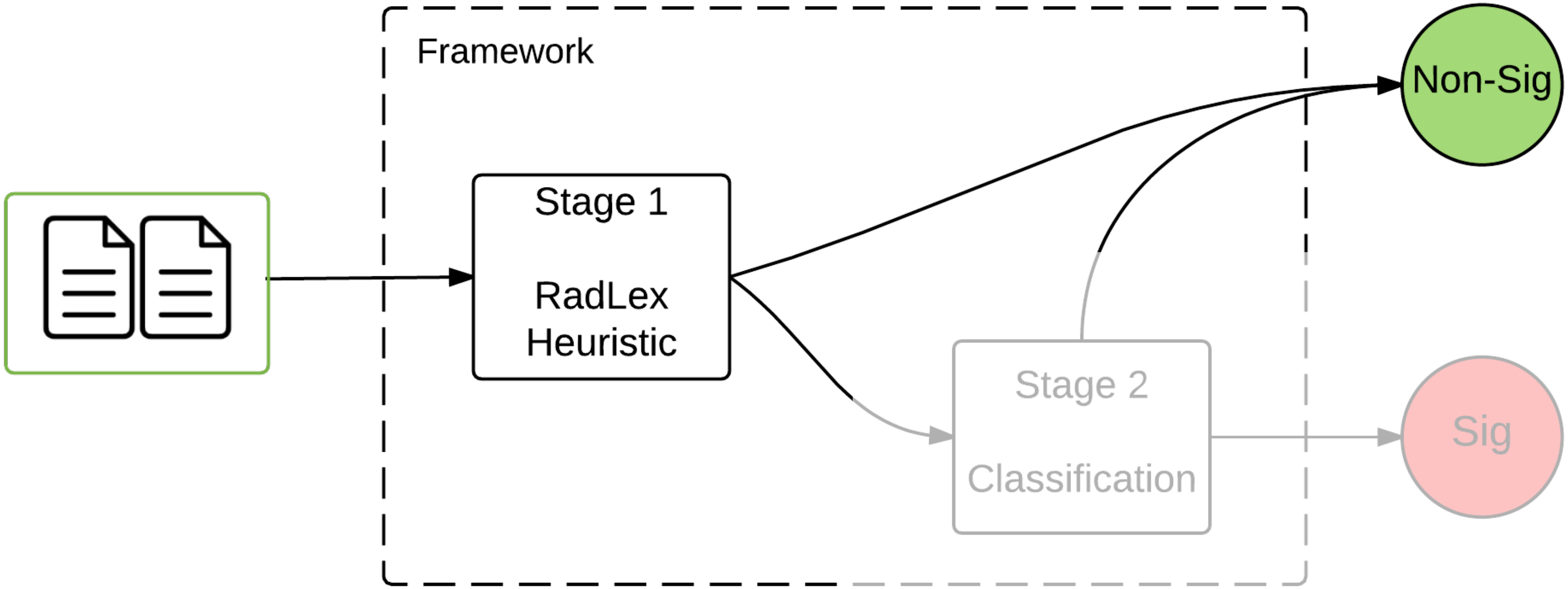
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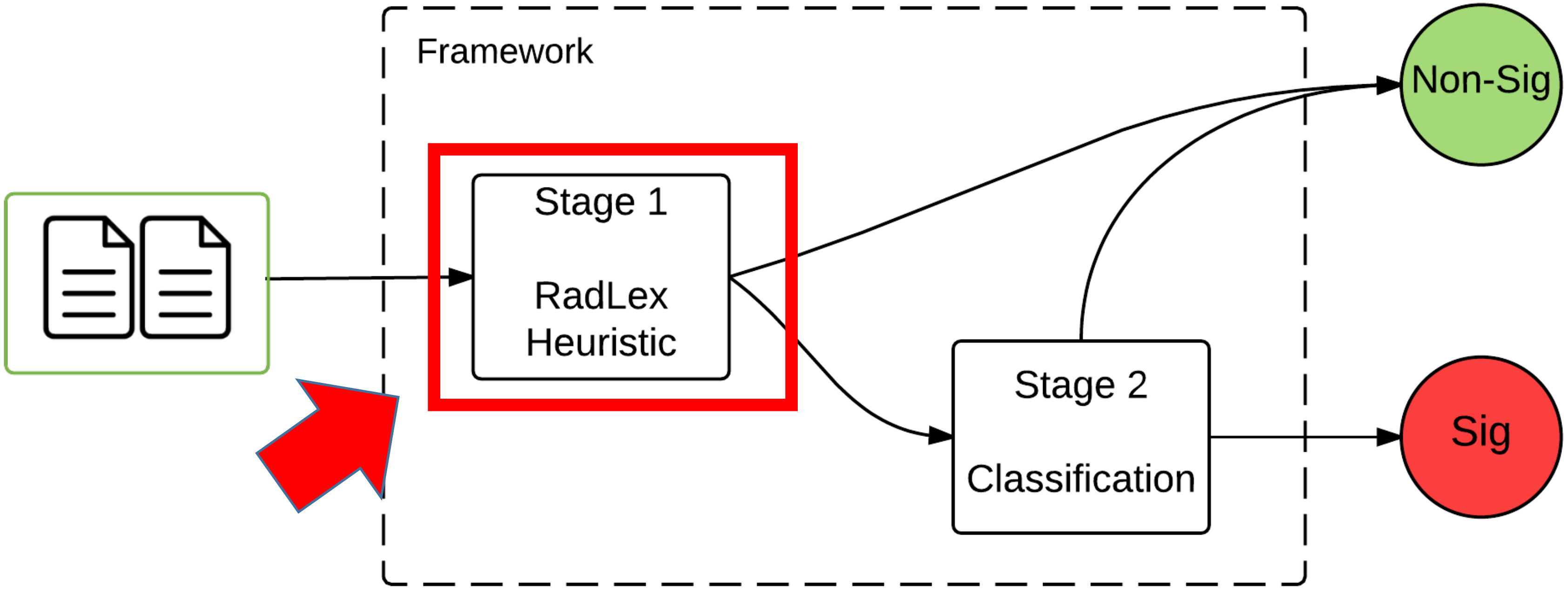
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Stage 1: Radlex heuristic

- If the Radlex terms are identical and negations are consistent, classify as non-significant
- Compare domain specific concepts (Radlex Ontology)

Prem. : "… There is a diffuse, dense, airspace opacity occupying most of the …"
Final: : "… diffuse, dense, airspace opacity occupying left frontal …"

- Negations:

Prem. : "… hypodensities in the inferolateral left frontal lobe …"
Final: "… **no** hypodensity in the inferolateral left frontal lobe …"

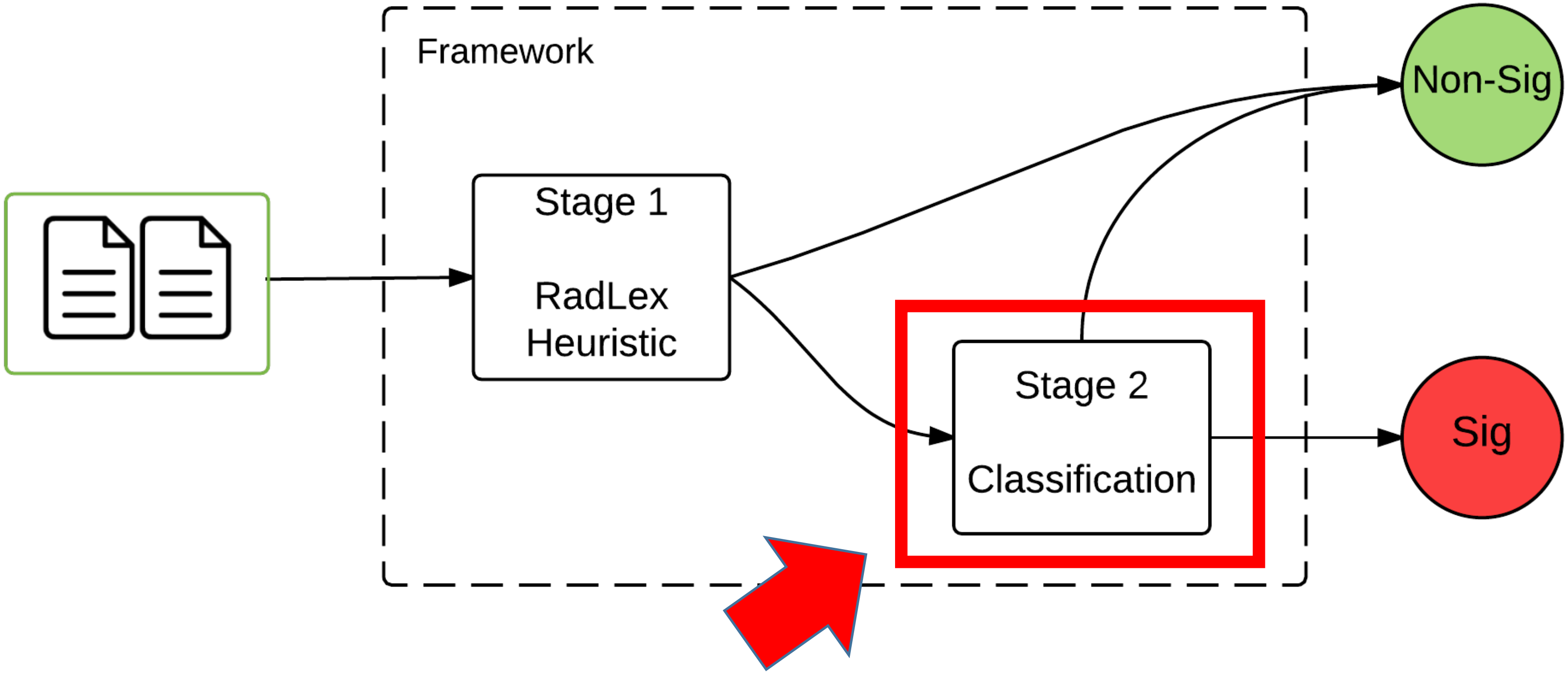
Stage-1: Radlex heuristic

		Radlex	Human A	Human B
Non-Significant	Radlex	1.0	0.964	0.942
	Human A	0.946	1.0	0.906
	Human B	0.942	0.906	1.0
Count=139	Fleiss $\kappa = 0.880$			

Stage-1: Radlex heuristic

		Radlex	Human A	Human B
Non-Significant	**Radlex**	1.0	0.964	0.942
	Human A	0.946	1.0	0.906
	Human B	0.942	0.906	1.0
Count=139	Fleiss $\kappa = 0.880$			
Significant	**Radlex**	1.0	0.557	0.492
	Human A	0.557	1.0	0.934
	Human B	0.492	0.934	1.0
Count=61	Fleiss $\kappa = 0.468$			

Overview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Stage 2: Classification

- Use textual features designed for capturing the differences between the reports.
- Feed this features to a classifier

Features

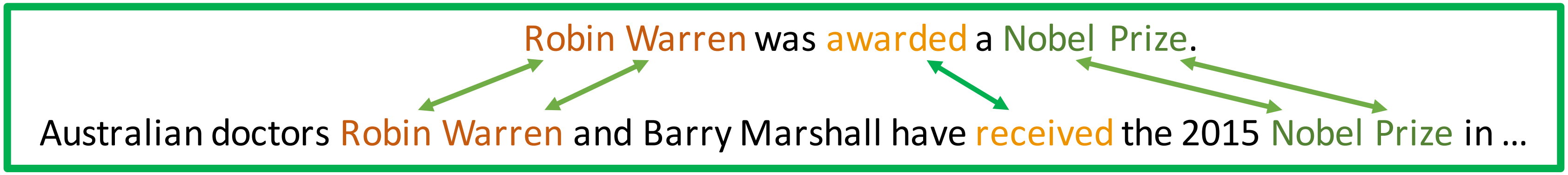
- Surface Textual Features
  - Character, word and sentence differences
- Summarization evaluation features
  - ROUGE: Evaluation metric based on text overlaps
    - Take the final report as the gold standard and compute the ROUGE score of the preliminary report
    - Higher scores → Differences are less significant → Higher quality of preliminary report

Features

- ROUGE-N:
  - N-Gram precision and recall
- ROUGE-L:
  - Sequence differences (LCS)
- ROUGE-S:
  - Skip-Bigram co-occurrence

Features

- Machine Translation Evaluation Metrics
  - Take the final report as gold-standard
  - Evaluate the quality of the preliminary report
    - BLEU: Similar to Rouge-N, except being precision-oriented. With brevity penalty
    - Word Error Rate (WER)
    - METEOR: Based on alignment, considers synonyms



Robin Warren was awarded a Nobel Prize.

Australian doctors Robin Warren and Barry Marshall have received the 2015 Nobel Prize in …

Features

- Readability assessment
  - Quantify and compare the reporting stylistic characteristic of the reports
    - Automated Readability Index (ARI)
    - Simple Measure of Gobbledygook (SMOG) index
    - Average of phrase counts

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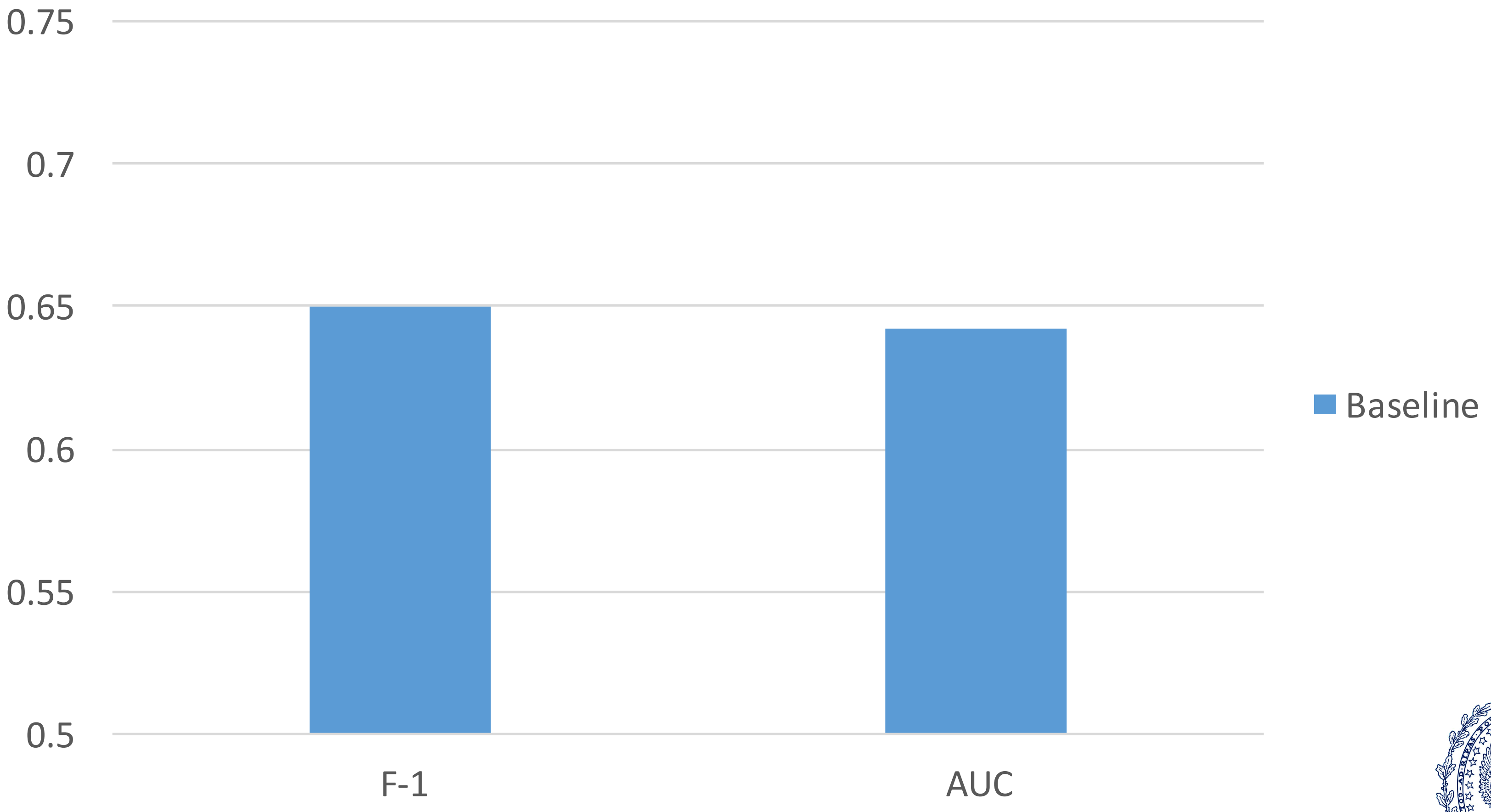
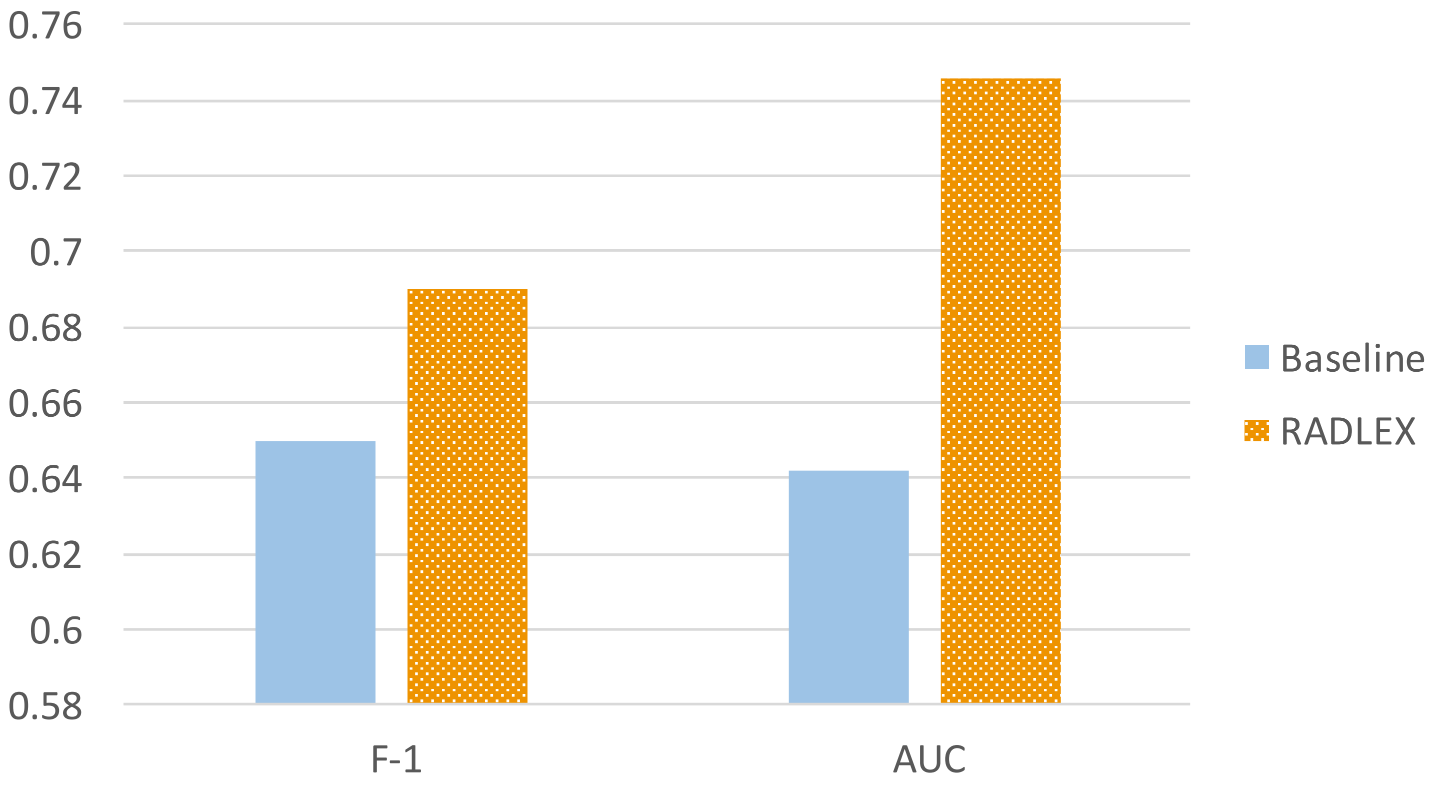
Evaluation

- Stage 1 – Radlex Heuristic
  - 200 Manually annotated reports
- Stage 2 – Classification approach
  - 150 Manually annotated reports

Results



Results: Individual Features



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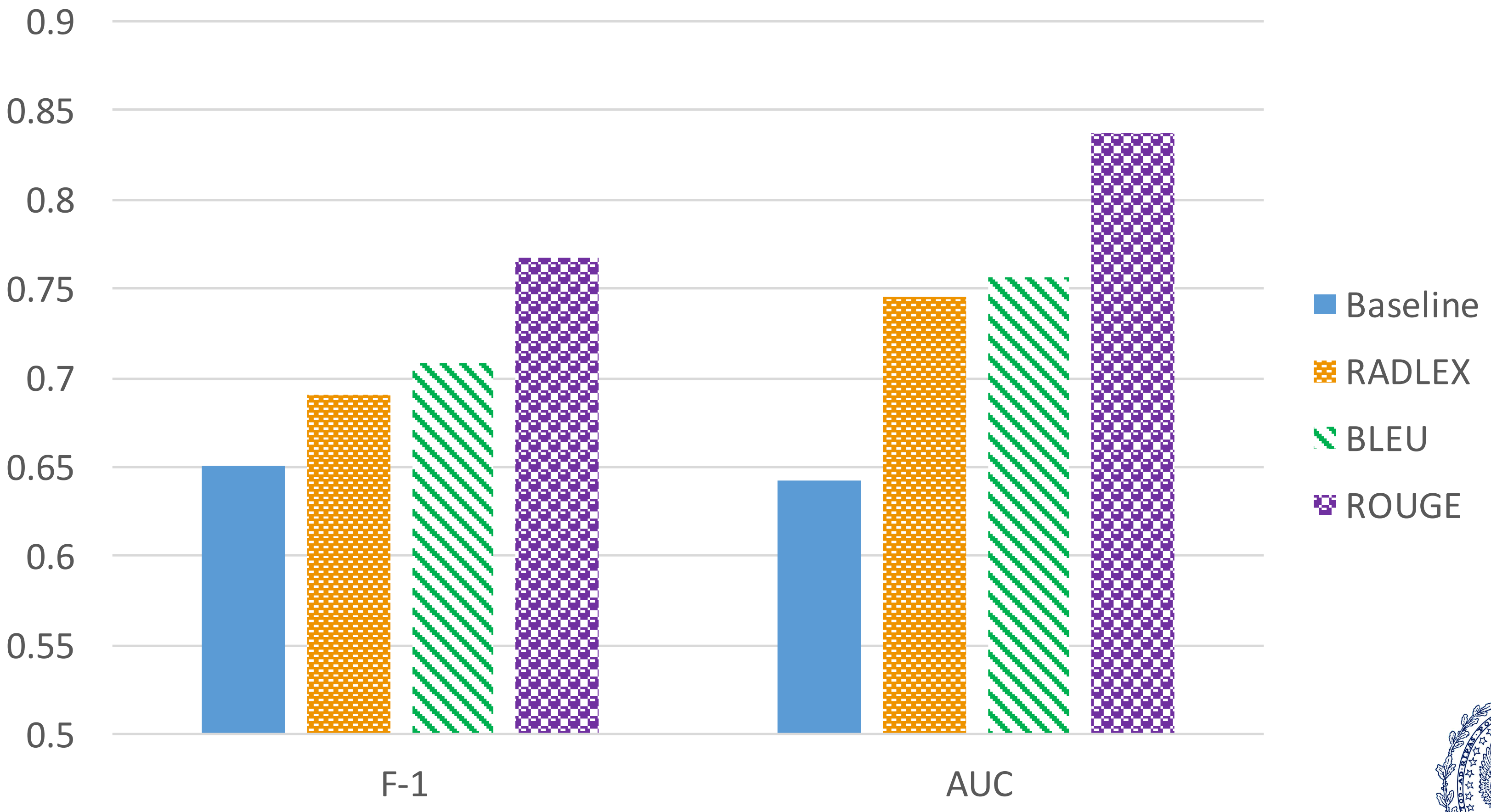

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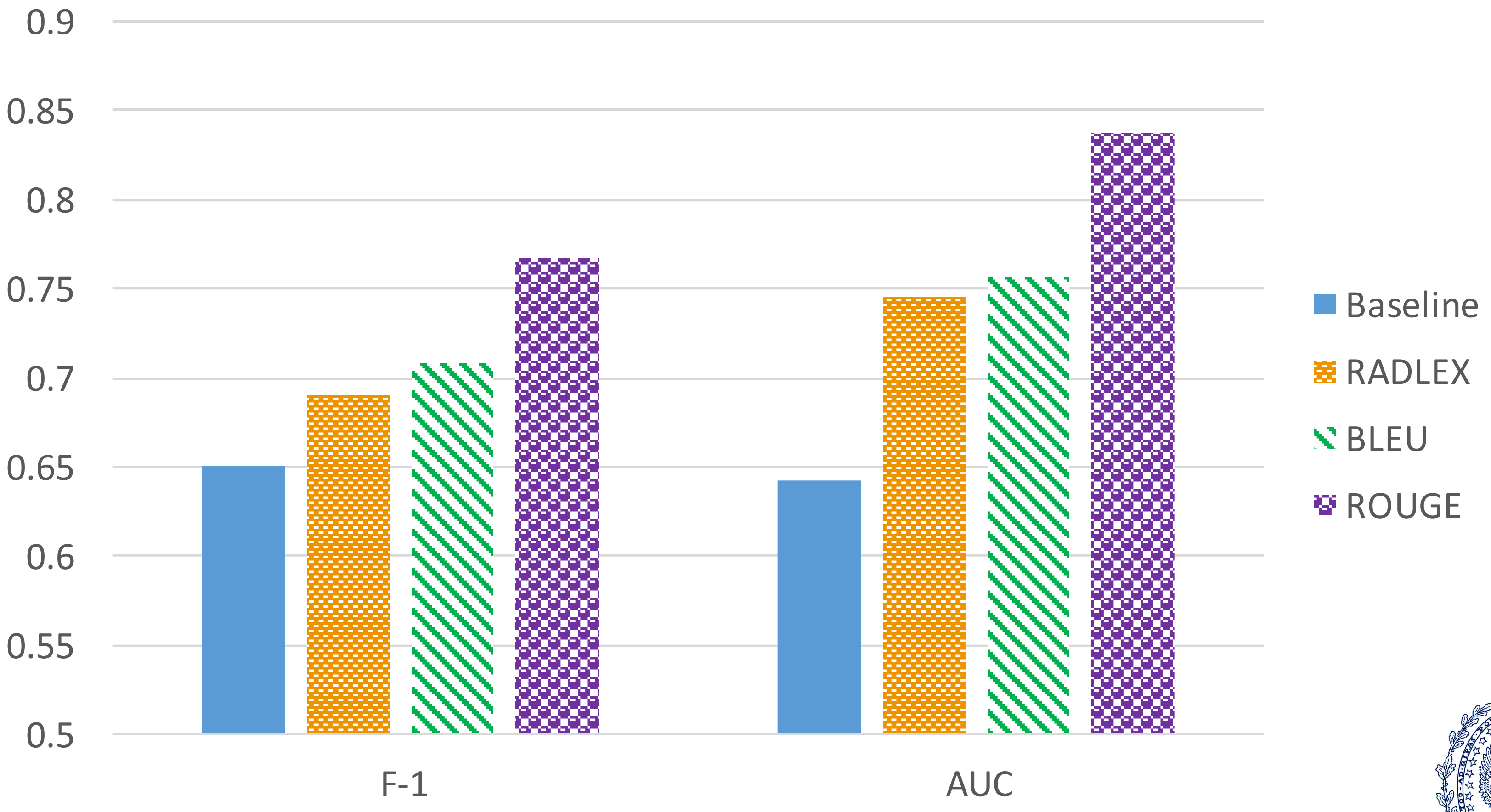

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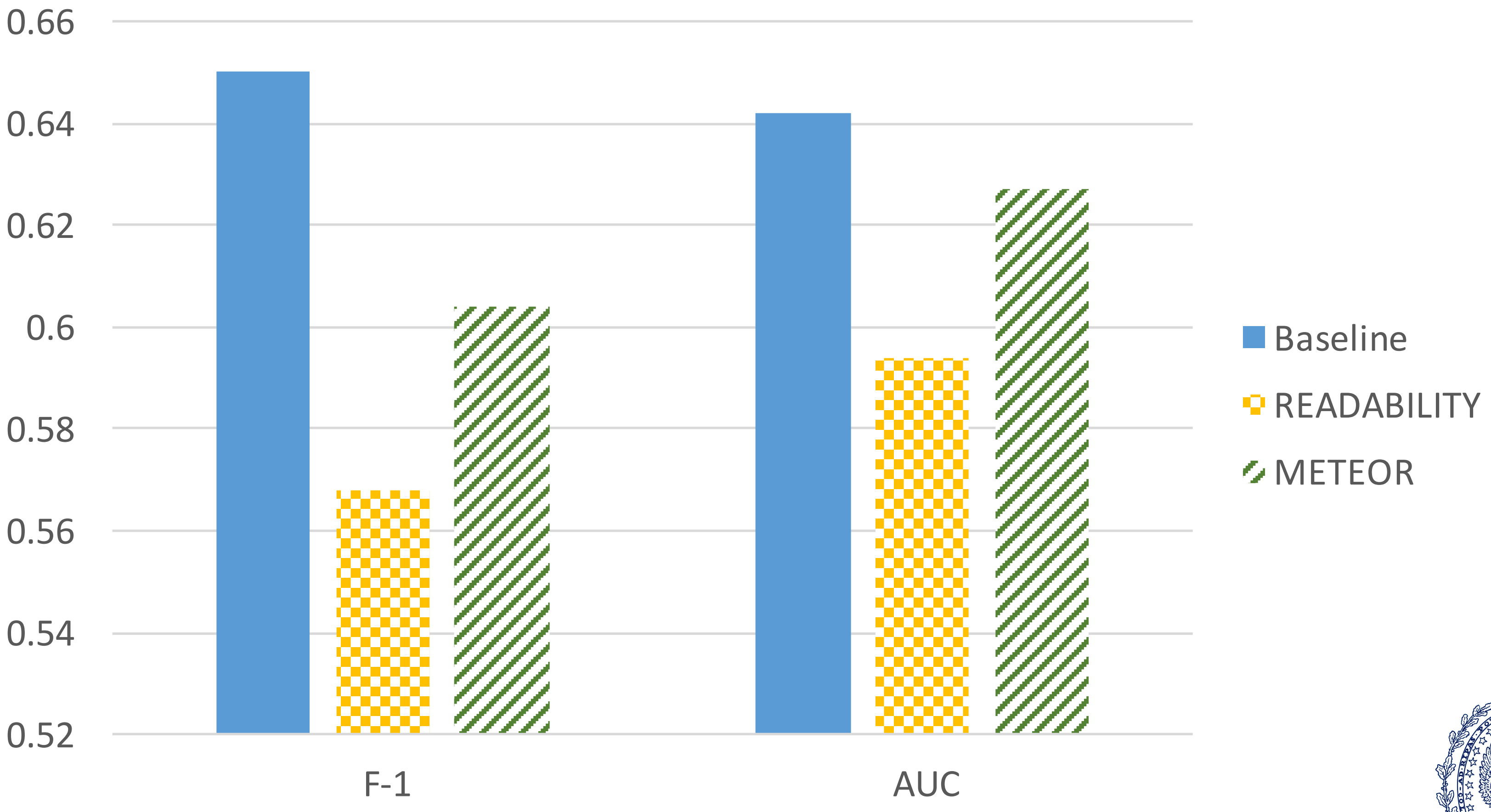
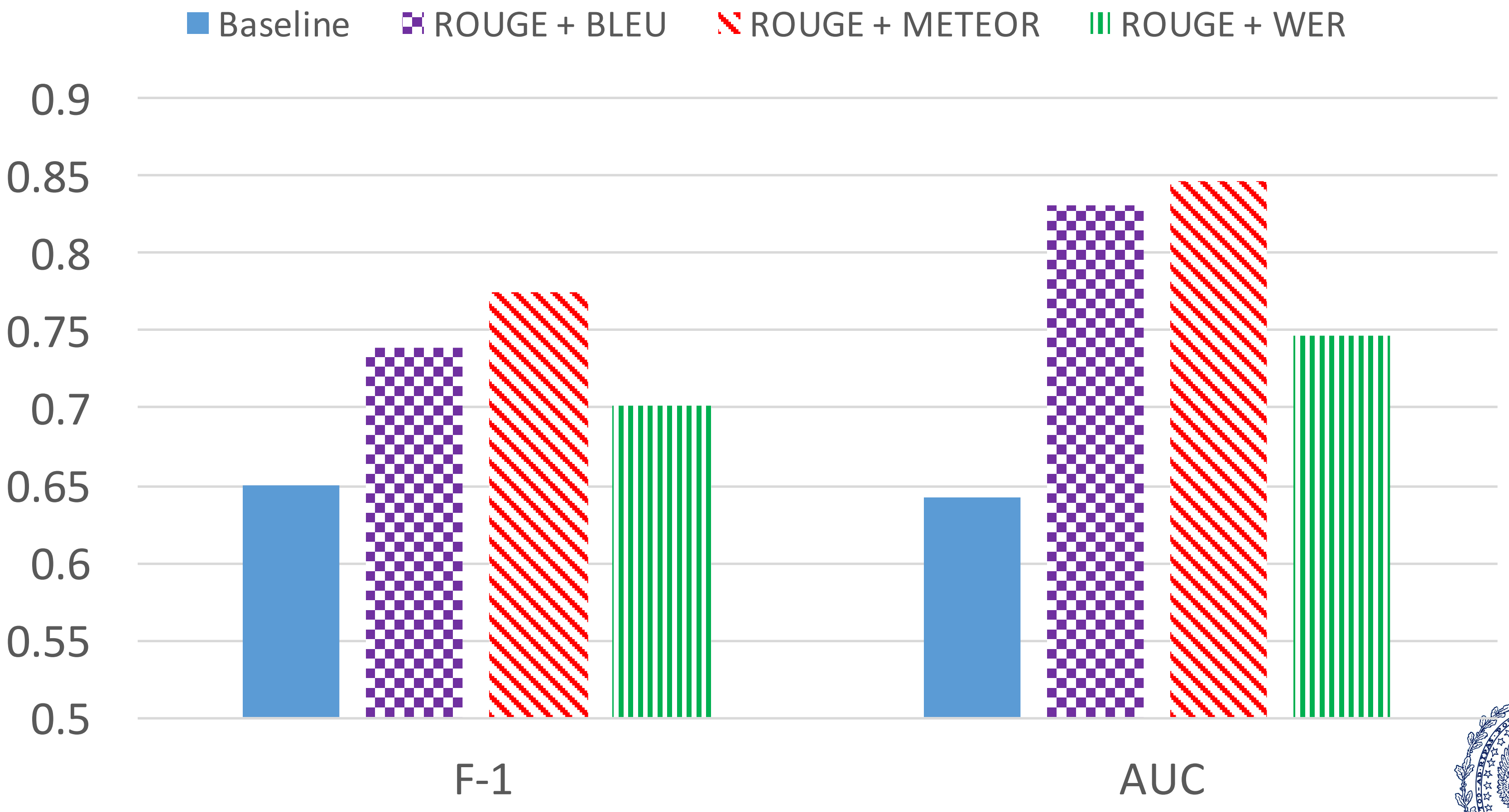


Feature Combinations

Summarization and MT



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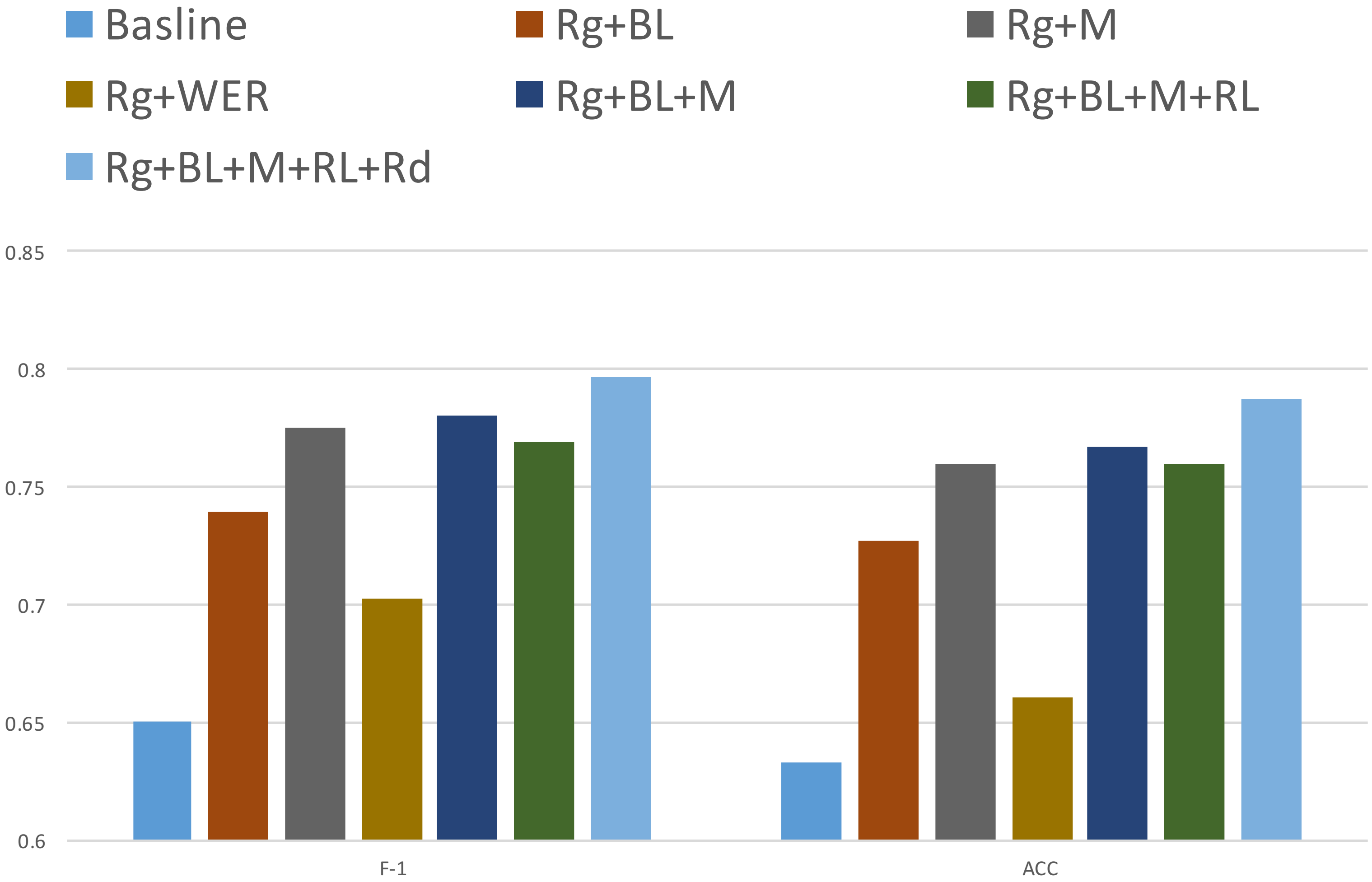

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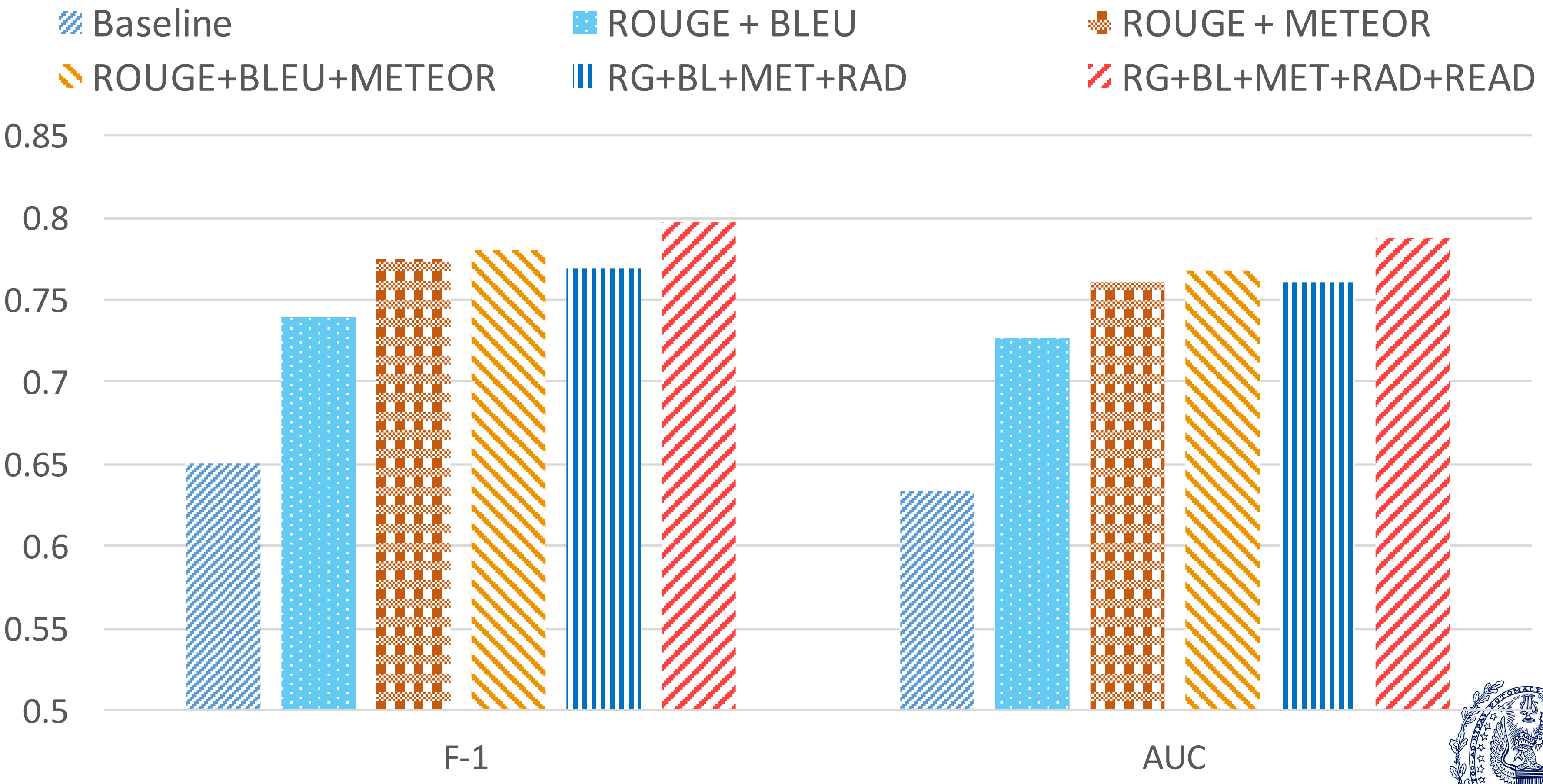

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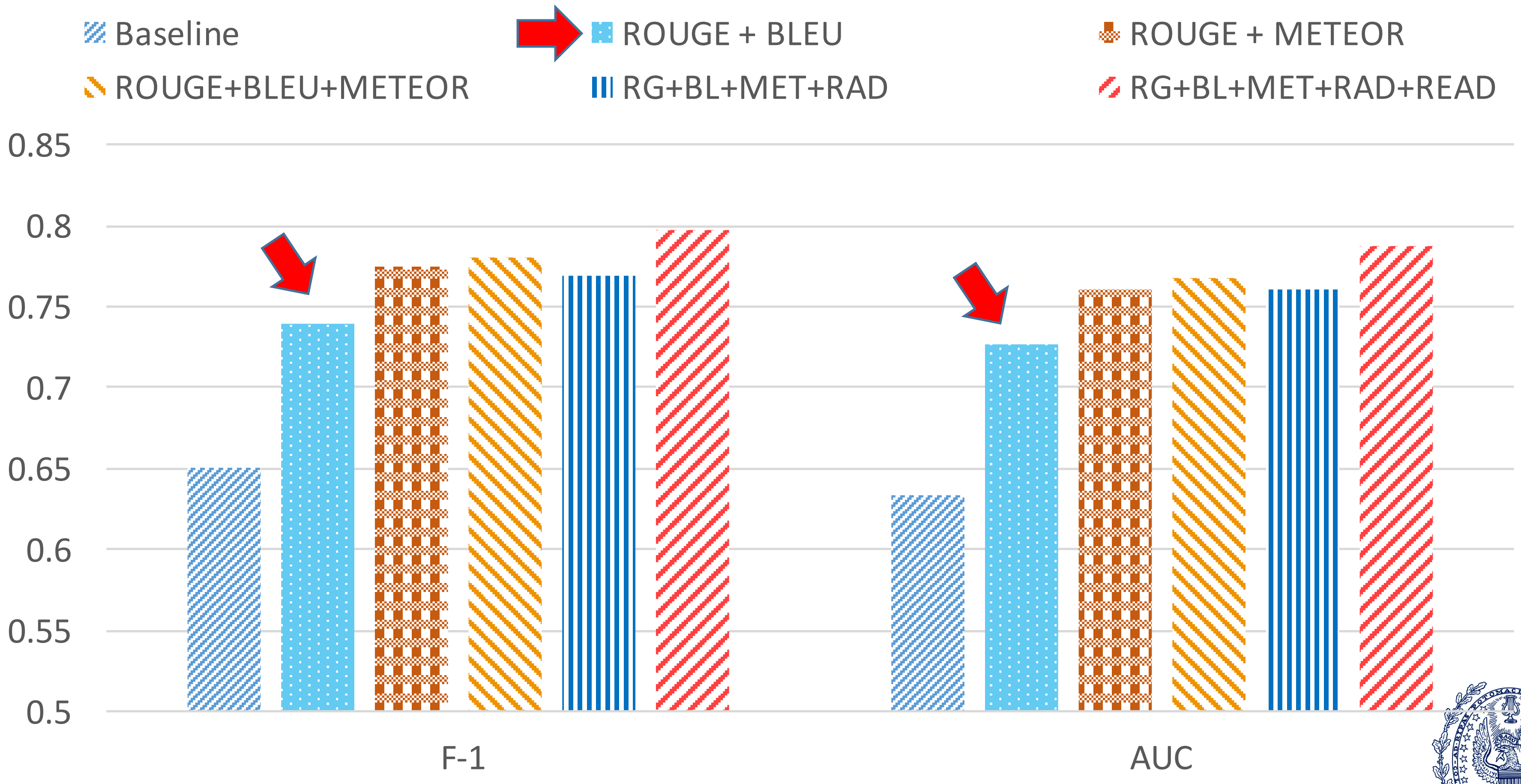

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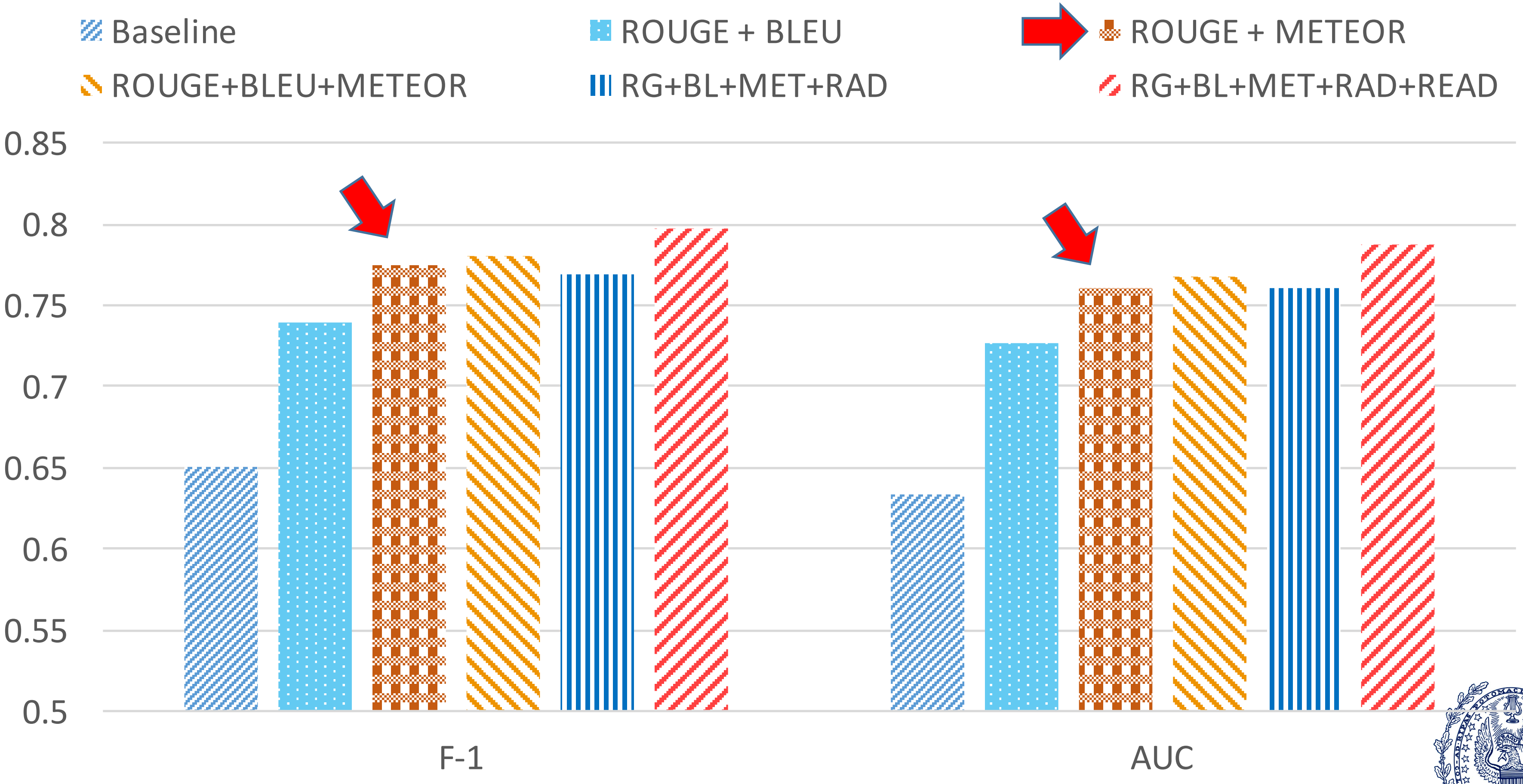

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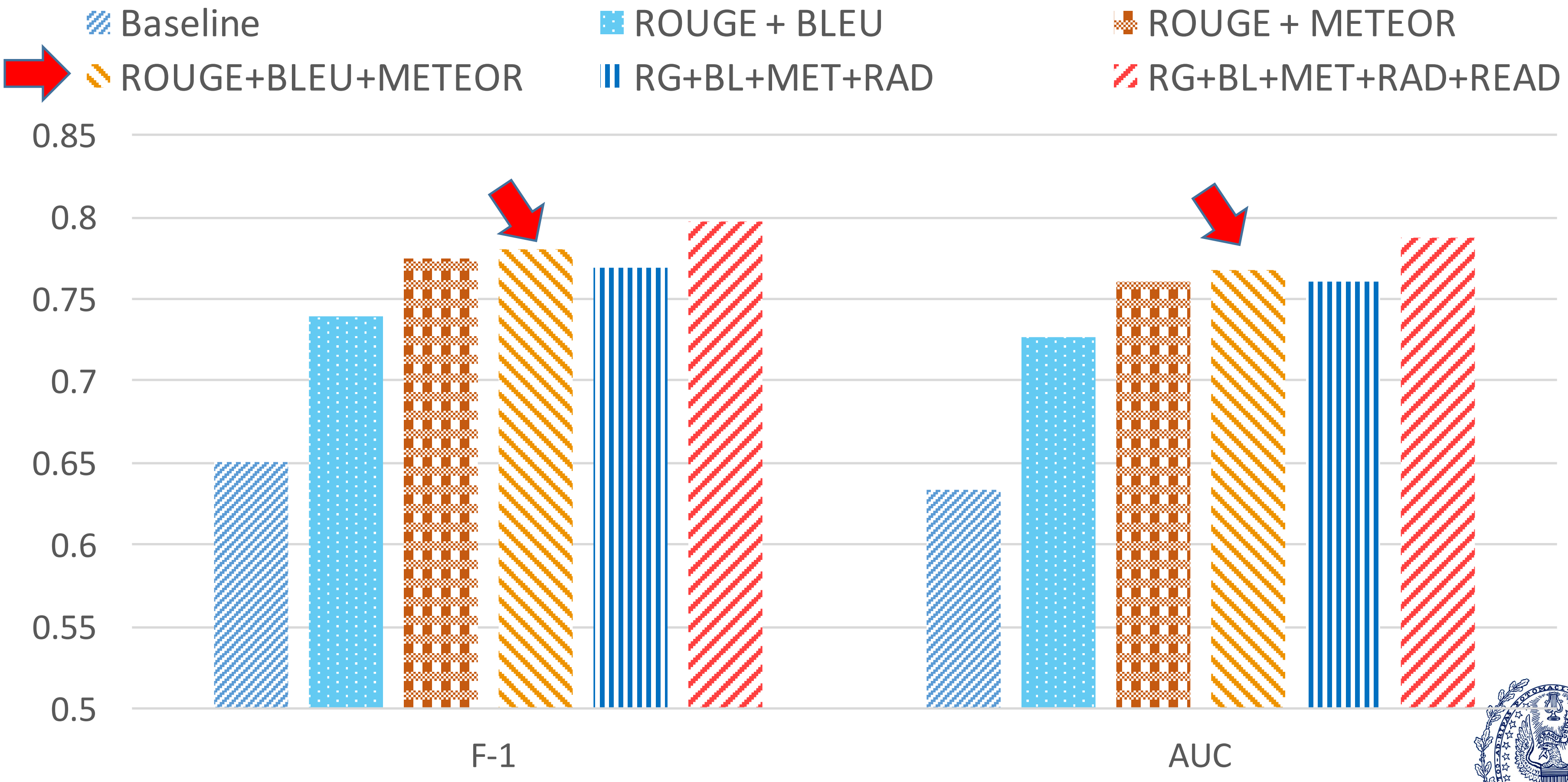

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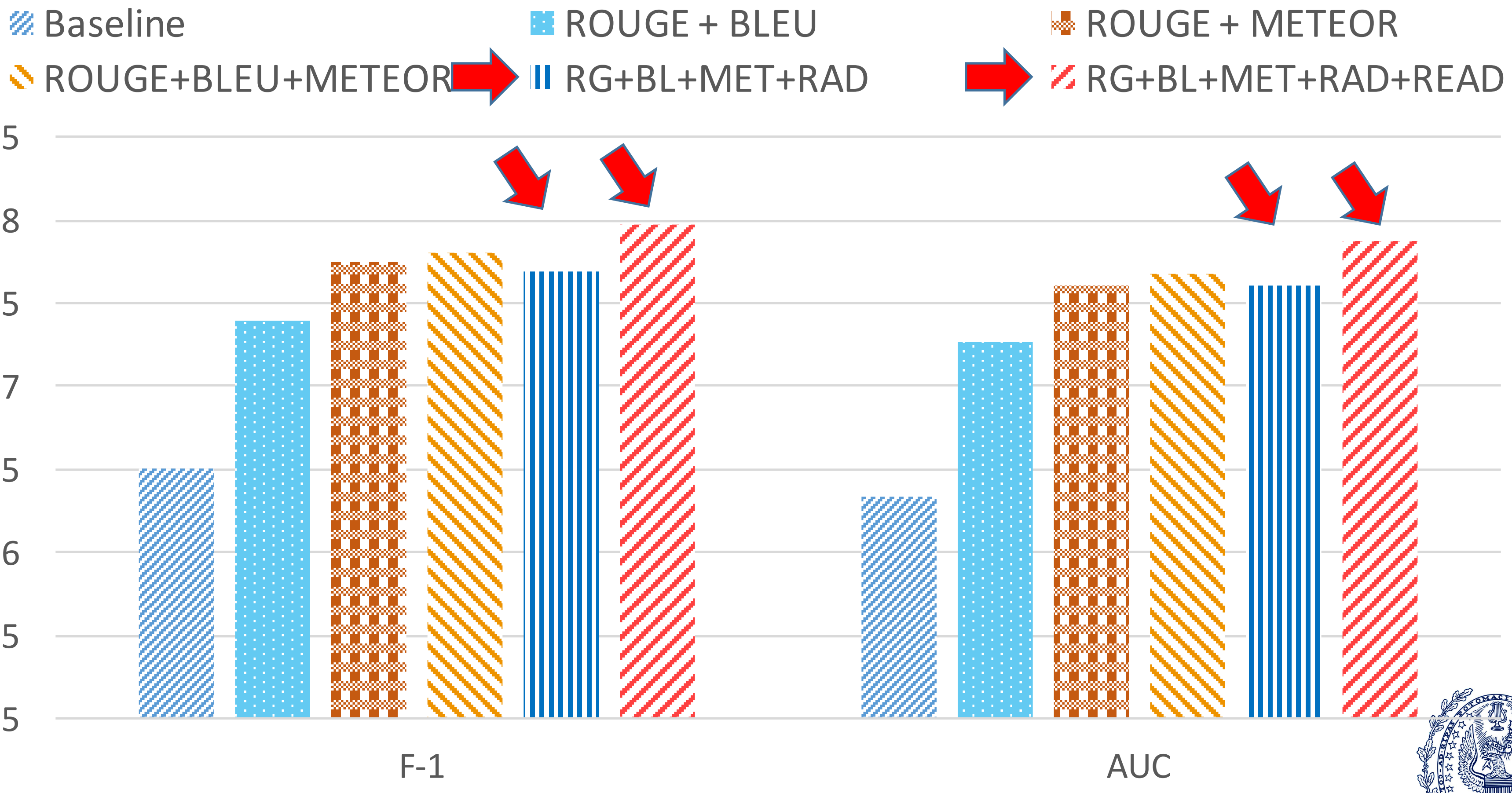
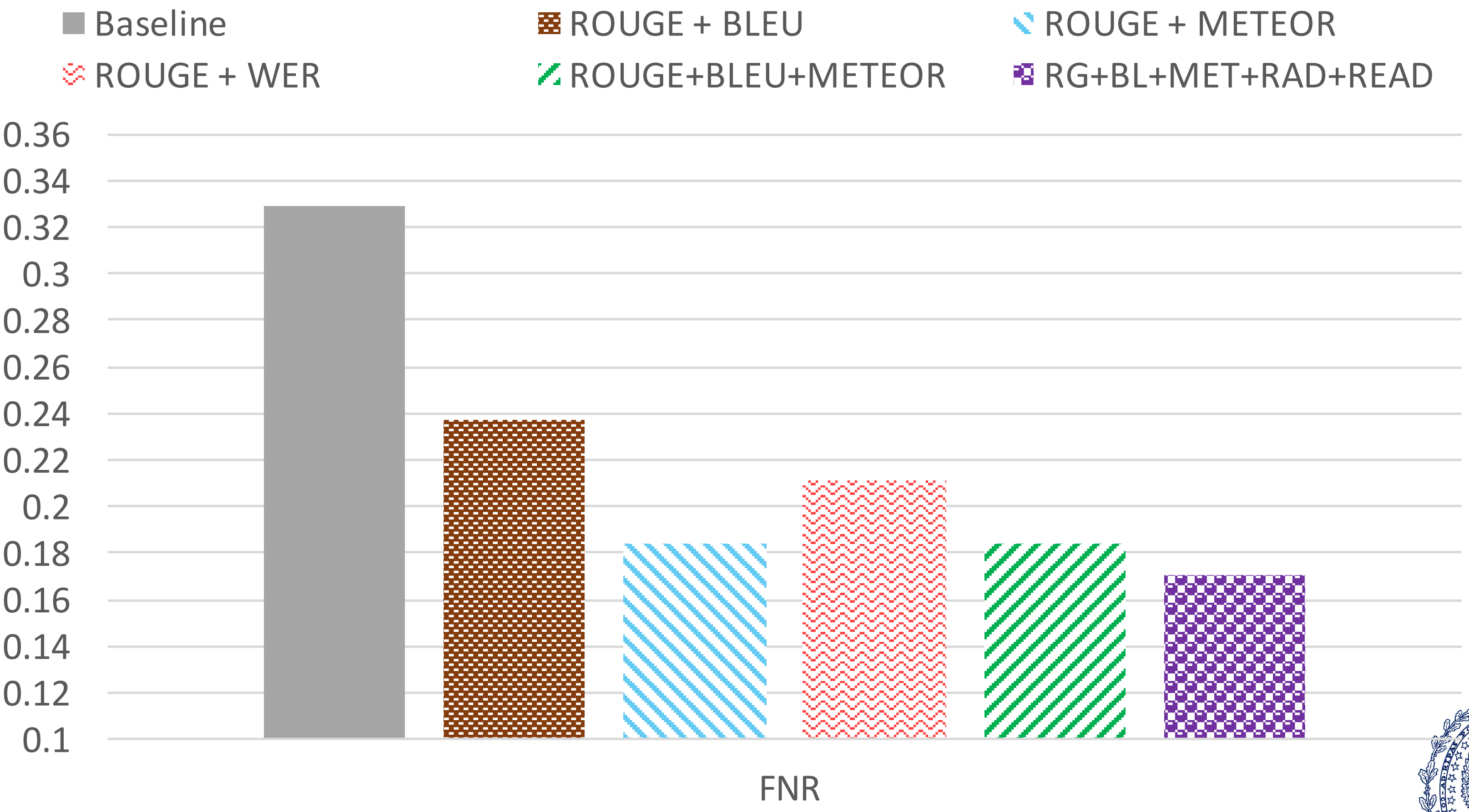
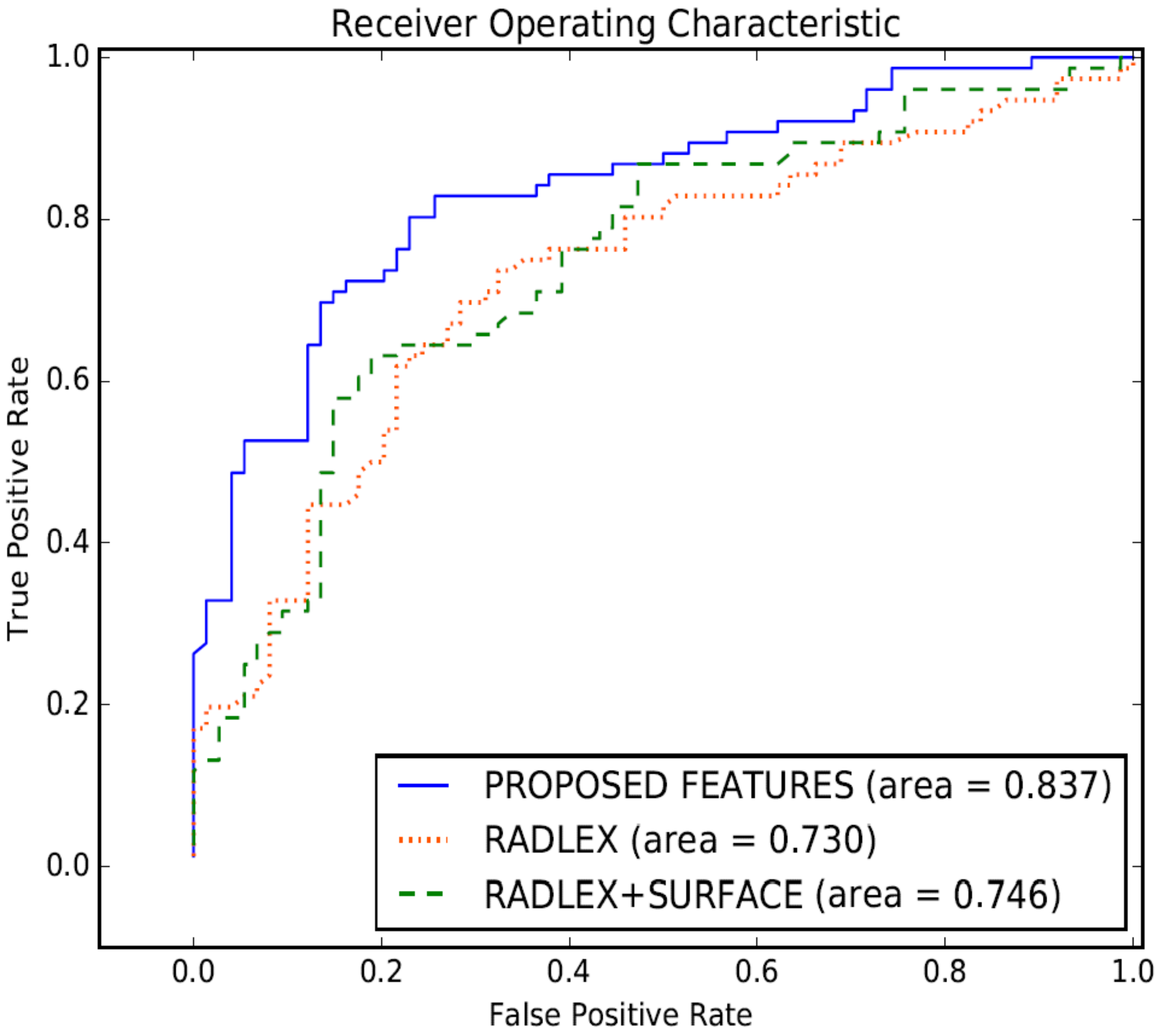


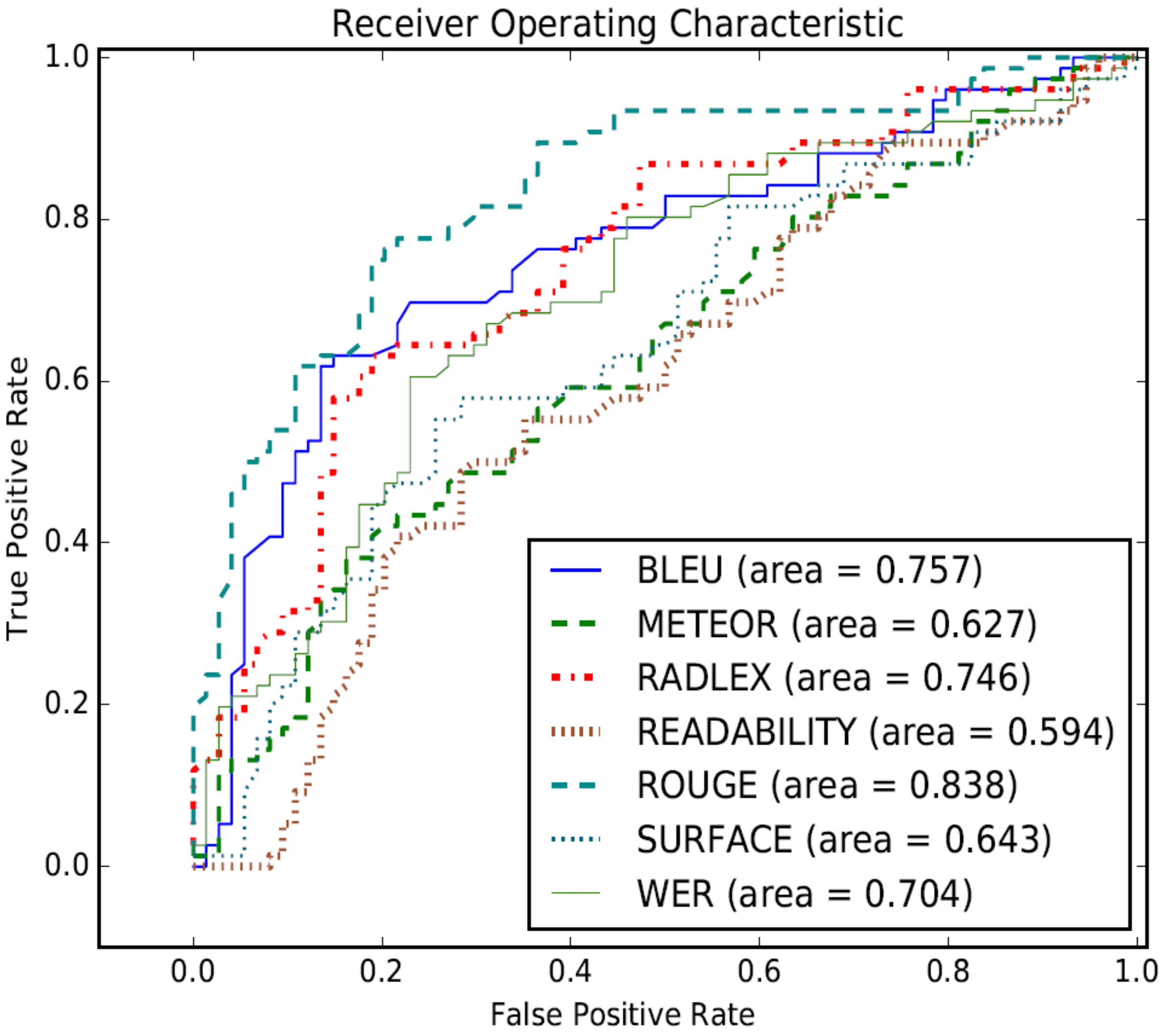
False Negative Rate



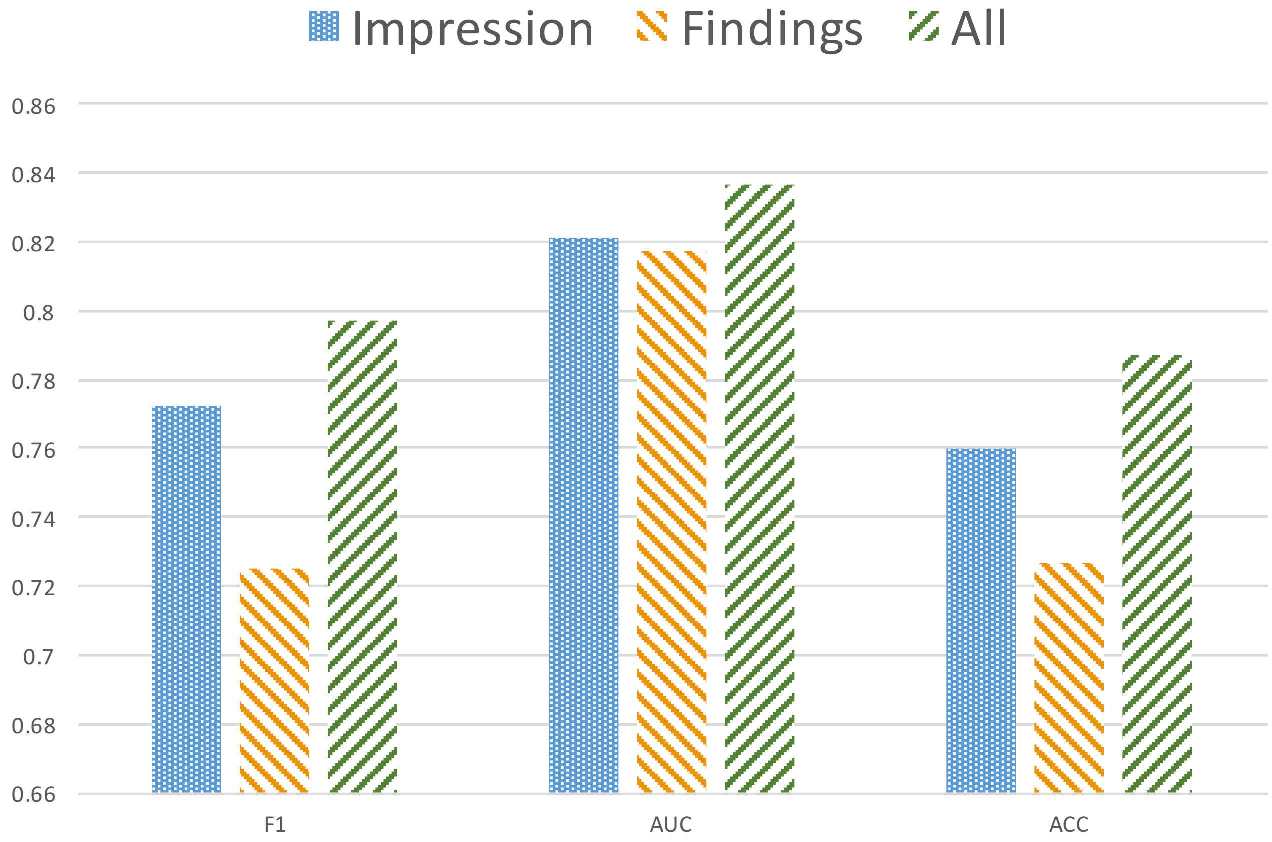
Proposed Features vs Baseline



Feature Comparison



Is summary enough?



Identifying Significance of Discrepancies in Radiology Reports (SDM-DMMH 16)

Error analysis

- False positive cases
  - Unnecessary long length of preliminary reports that were removed in the final version
- False negative cases
  - Very slight change that alters the significance

Prem. Report: Worsening airspace disease at the left base represents aspiration.

Final Report: Worsening airspace disease at the left base could represent aspiration.

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Summary

- We can utilize metrics used for evaluation tasks as features for text comparison
- Our two-stage approach effectively identifies the significant discrepancies (79.7 F-1, 17.1 FNR)
- There are special cases that the current features are not designed to handle

Thank you!

Questions?

www.ArmanCohan.com