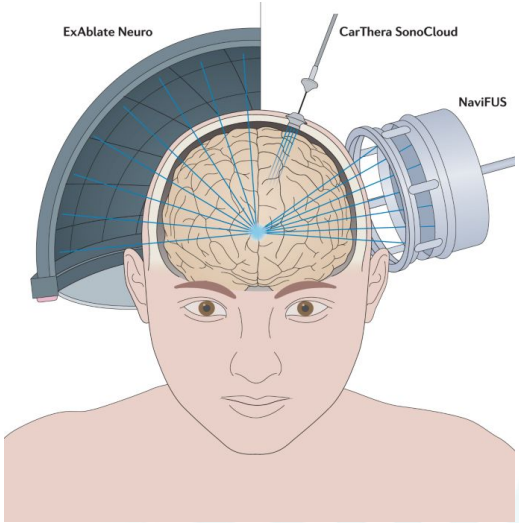
Progress Presentation

Sponsors: Focused Ultrasound Foundation
Faculty Mentor: Heman Shakeri
Student Team: Rose Eluvathingal Muttikkal, Abhishek Singh, Skye Jung, Reanna Panagides

Project Purpose and Background

- **Problem:** The current literature review process is timely, inefficient, and prone to error

- **Proposed solution:** Utilize ***machine learning techniques*** to enhance the efficiency of ***classifying scientific literature*** about ***emerging applications*** and ***indications*** of focused ultrasound therapies



Meng et al, 2021

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Project Plan

Updates 1/26/24

```
0    441
1     48
Name: fus_related, dtype: int64
```

Sean's work

- Retrieve articles related to ***ML/AI*** in focused ultrasound or its related domains
- ***PDF processor*** that enables users to input any PDF article
- Article summarized → ***ChatGPT's API***/analyzer that rates sentence relevance
- ***Classification*** of articles → FUS/Non-FUS, Supervised/Unsupervised)

```
prostate                          6
UF                                4
AD                                3
bone mets                         3
liver                             3
ET, PD                            2
obesity                           2
stroke intracerebral hemorrhage   2
pd                                2
DIPG                              2
uf                                2
tendon contracture                1
spinal cord injury                1
soft tissue tumors                1
ut adenomyos                      1
Retained placenta                 1
Ablation- other                   1
OCD                               1
PD                                1
Pancreatic ca                     1
lichen sclerosis                  1
heart failure                     1
GBM                               1
ET,                               1
cervicitis                        1
Cervical cancer                   1
atherosclerosis                   1
ut adenomyosis                    1
Name: ind_list, dtype: int64
```

Updates 2/9/24

SPRINT 2 - Model(s) Building		02/01	02/14

- Sean Meeting
  - Current usage of Sean's work?
  - Cost to host Sean's work?
- Obtaining summer data? (Samarth + Eric)
- SIEDS Abstract
  - https://docs.google.com/document/d/1TsKA0zhi0HTdYaJ6m2Ui5fgWGKMLzGtCrjeQSBfLA6I/edit?usp=sharing
  - Co-author?
- Currently working on…
  - Running previous scripts locally → app.py, model file
  - Web scraping FUS website
  - Running BERT model on "test data"

Updates 2/21/24

- **Sprint 2 (Model Building) Complete**
  - Finished SIEDS Registration
  - Sean's work
    - Met with him
    - Got access to Sean's data (~90 labelled manuscripts)
    - Understood model development (limitations)
  - Ran BERT mode on "test data"
- **Started Sprint 3 (Train + Evaluate models)**
  - Training and test DistilBERT (FUS/non-FUS)
  - Training and test SVM, log regression, naive bayes (FUS/non-FUS)
  - Train and test another BERT (FUS/non-FUS)
  - Training and test multiclass BERT (indications)
  - ***Project Progress Report 1***

Updates 3/22/24

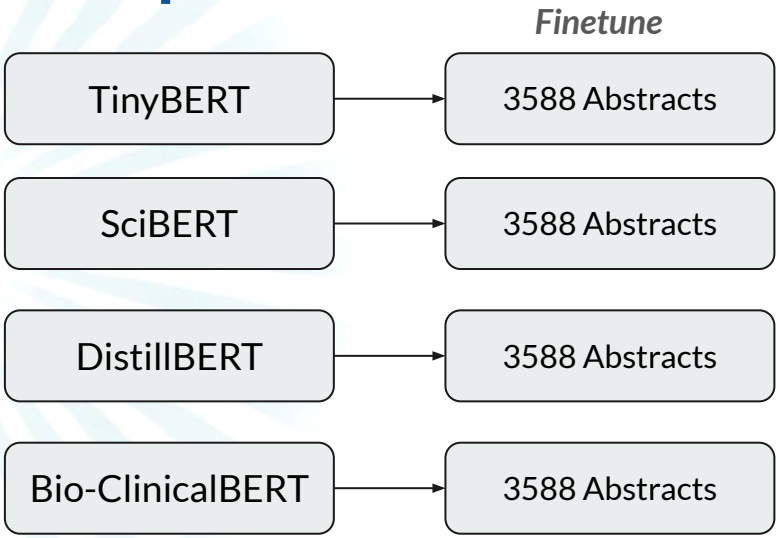
SPRINT 4 - Resolve Model Issues		02/29	03/27	42	28			
Compile supplementary data source (sean's data, fusf website data, zotero databse) organize data sources	Rose	02/29	03/27	42	28	In Progress		
Clean data before tokenisizing (get rid of background objective other filler words)	Rose	02/29	03/27	42	28	In Progress		
Create template of final report in overleaf	Reanna	02/29	03/27	42	28	Complete		
Start documenting process of model creation in overleaf final report	All	02/29	03/27	42	28	In Progress		
Start working on multi-class model	Skye	02/29	03/27	42	28	In Progress		
Make a workflow map → datasource → train-test split → model (epochs), other fine tuning steps…	Rose	02/29	03/27	42	28	In Progress		
Finish FUS/non-FUS classification (DistilBERT, old models, tinyBERT, medBERT, docBERT)	All	02/29	03/27	42	28	In Progress		

Updates 4/5/24

- **Updates on dataset - zotero_data.csv**
  - All articles in Zotero database (except veterinary)
  - Non-FUS - “ultrasound diagnostic” in PubMed article titles
- **Best model - SciBERT**
- **Tags instead of multiclass classification**
- **Next Sprint:**
  - Additional dataset from most recent Pubmed extraction
    - September 2023-March 2024
    - Example cases
  - Compiling/comparing models
  - Hyper-parameter fine-tuning
  - Model inferencing
  - Excel script
  - Finish SIEDS paper
  - Meet with data management team

```
{'eval_loss': 0.2066207230091095,
 'eval_accuracy': 0.947075208913649,
 'eval_f1': 0.9493333333333334,
 'eval_precision': 0.9035532994923858,
 'eval_recall': 1.0,
 'eval_runtime': 1.5817,
 'eval_samples_per_second': 226.966,
 'eval_steps_per_second': 14.541,
 'epoch': 1.0}
```

Recap



Training

2906 Abstracts
~80% of dataset

Hyper-params

323 Abstracts
~9% of dataset

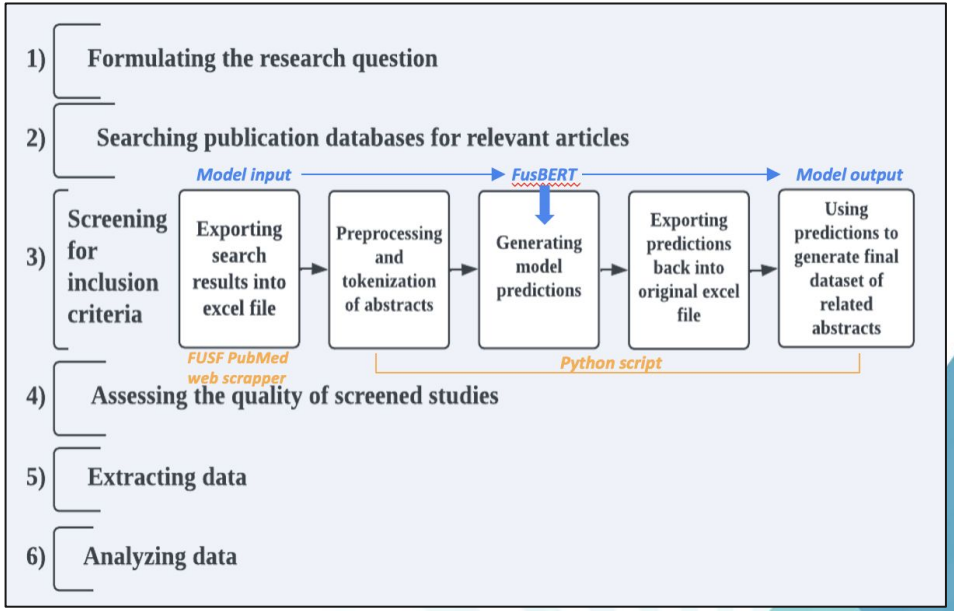
Testing

359 Abstracts
~10% of dataset

Recap

Model	Accuracy	Precision	Recall	F1
Naive Bayes	0.87	0.89	0.87	0.87
SVM	0.89	0.90	0.89	0.89
Logistic Regression	0.90	0.91	0.90	0.90
TinyBERT	0.88	0.82	0.98	0.89
SciBERT	0.89	0.89	0.99	0.90
DistilBERT	0.90	0.84	0.99	0.91
Bio-ClinicalBERT	0.91	0.85	0.99	0.91

TABLE IV: Performance comparison of different models



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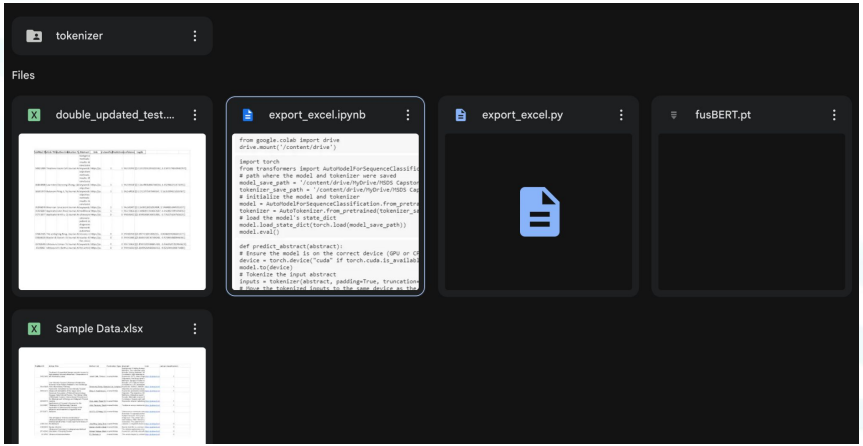
Recap

PubMed ID	Article Title	Author List	Publication Type	Abstract	Link	(actual classification)	Prediction	Confidence	Logits
34921489	Treatment of super	Jacek Calik, Tomas	Journal Article	Background: Existing therapeu Methods: Two volunteer subj Results: During treatment, blo Conclusion: High intensity foc Keywords: HIFU; cherry angio	https://pubmed.ncl	1	1	97.51520753	[[-1.6755231618881226, 1.994294285774231]]
36444908	Low-Intensity Focu	Shenrong Zhong, Qianyun Cai, Longhe Zl		Objectives: This study aims to Methods: Sprague-Dawley rat Results: LIFU reduced heart ra Conclusions: LIFU ameliorates Keywords: AchRα7; HMGB1; T	https://pubmed.ncl	1	1	97.46402502	[[-1.6663931608200073, 1.9825135469436646]]
36541473	Autonomic modula	Ning Ji, Yuanheng	Journal Article	Objective.Our previous study Keywords: autonomic modula	https://pubmed.ncl	1	1	97.73917198	[[-1.7370295524597168, 2.0295417308807373]]
35396078	American Associati	Sina Jasim, Kepal I	Journal Article	Objective: The objective of thi Methods: A literature search v Results: Minimally invasive th Conclusion: Surgery and radio Keywords: ethanol; radiofrequ	https://pubmed.ncl	1	1	97.89092541	[[-1.7765820026397705, 2.061021089553833]]
35326687	Applications of Foc	John Panzone, Tin	Journal Article	Traditional cancer treatments	https://pubmed.ncl	1	1	97.96125293	[[-1.7842141389846802, 2.0880227088928223]]
25753877	Application of ultra	W-X Fu, Q Wang, '	Journal Article	Ultrasound is commonly used	https://pubmed.ncl	0	0	99.07332659	[[2.402134895324707, -2.2698824405670166]]
37682185	The ambiguous "in	Jing Ning, Gang Zh	Journal Article	Rationale: Congenital anatom Patient concerns: A 61-year-ol Diagnoses: The patient was di Interventions: After relevant p Outcomes: The patient recove Lessons: Congenital absence c	https://pubmed.ncl	0	0	99.40914512	[[2.568174362182617, -2.557249069213867]]
22608626	Bipolar disorder	Daniel J Smith, Eli	Journal Article	Bipolar disorder is a serious di	https://pubmed.ncl	0	0	99.82409477	[[3.3475353717803955, -2.9937052726745605]]
28748549	Ultrasound Curricu	Usman Tarique, Bı	Journal Article	The clinical applications of poi Keywords: curricula; educatio	https://pubmed.ncl	0	0	99.76135492	[[3.210164785385132, -2.8253657817840576]]
3519082	Ultrasound instrum	R J Bartrum Jr	Journal Article	This article begins by reviewin	https://pubmed.ncl	0	0	99.5505929	[[2.7637088298797607, -2.636791467666626]]

Demo

https://github.com/rteb8/MSDS_FUSCapstone23/tree/main

1. Access handover files
   - Google drive folder - FUS_handover
   - Github repo - “handover” folder, access fusBERT.pt using huggingface
2. Modify + run *export_excel.ipynb*
   - We recommend using google colab to execute .ipynb file



Demo

https://github.com/rteb8/MSDS_FUSCapstone23/tree/main

1. Runtime to PyTorch 2.0.1, Hardware accelerator to T4-GPU
2. Install torch, transformers, pandas, openxyl packages
   - pip install torch, pip install transformers, pip install pandas, pip install openxyl
3. Make sure excel file is in folder/repository where the .ipynb file is
   - Use "*Sample Data.xlsx*" for demo
4. Edit .ipynb file to have the correct path, then run all cells in the file
   - model, tokenizer, input data, output file path

```
# path where the model and tokenizer were saved
model_save_path = '/content/drive/MyDrive/MSDS Capstone/FUS_handover/fusBERT.pt'
tokenizer_save_path = '/content/drive/MyDrive/MSDS Capstone/FUS_handover/tokenizer'
```

```
file_path = '/content/drive/MyDrive/MSDS Capstone/FUS_handover/Sample Data.xlsx' #update file path to relevant file
df = pd.read_excel(file_path)
```

```
# Save to a new Excel file
output_file_path = '/content/drive/MyDrive/MSDS Capstone/FUS_handover/double_updated_test.xlsx'
df.to_excel(output_file_path, index=False)
```

April Data

Actual classification

```
0    419
1     75
Name: fus_related, dtype: int64
```

Model prediction

```
1    493
0      1
Name: Prediction, dtype: int64
```

Potential Causes

- BERT models have lower precision scores than recall scores → may need to achieve higher precision scores
  - More likely to predict a ***false positive*** than ***false negative***
- Difference between non-FUS related articles BERT models used for training + monthly reviews
  - Initial dataset → 48 FUS related, 441 non-FUS
  - Final dataset → 1794 FUS related, 1794 non-FUS
- Articles on FUS changes over time ***(concept drift)***→ Feb-Aug 2023 + supplemental articles may be different than April 2024 articles

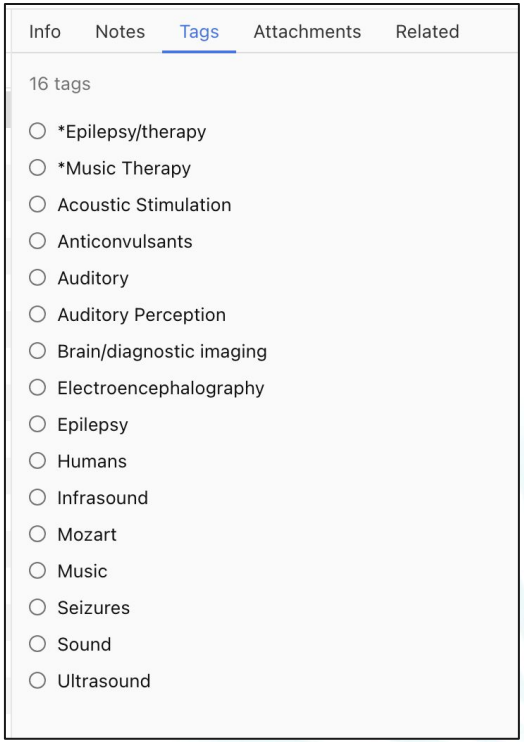
Recommendations

- Further work needs to be done before incorporating BERT models into literature review pipeline
  - BERT (language models) models are data intensive, initial dataset was too small and didn't have enough FUS-related articles to fine tune BERT models
    - Re-train BERT models → with only articles used for monthly literature review
    - Train models that are less data-hungry to perform classification
  - Assess difference between non-FUS articles in test dataset + April 2024 data
    - More guidance on labeling of "non-FUS" articles
  - Develop a feedback loop into the model pipeline which can incorporate human review of model output + learn from it
    - Address changes concept drift of FUS articles without needing to changing modeling approach

Future Work

- Multi-class classification of FUS manuscript indications
  - Modify PubMed web-scraper to pull in tags
- Explore other transformer architectures for text classification
- Develop feedback loop into modeling pipeline to address concept drift
- Incorporate “explainable AI” features into model prediction

Tags pulled in by Zotero



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Questions?