Assessing Disease Severity in Cutaneous Lupus Patients Using Natural Language Processing

UT Southwestern Medical Center

Laura Wang, BA[1], Kuroush Nezafati, MD[2], Ruichen Rong, PhD[2], Andrew Park, MD[1], Jane Zhu, MD[1], Guanghua Xiao, PhD[2], Yang Xie, PhD[2], Donghan M. Yang, PhD[2], Benjamin F. Chong, MD[1]

[1]Department of Dermatology, University of Texas Southwestern Medical Center [2]Quantitative Biomedical Research Center, Peter O'Donnell School of Public Health, University of Texas Southwestern Medical Center

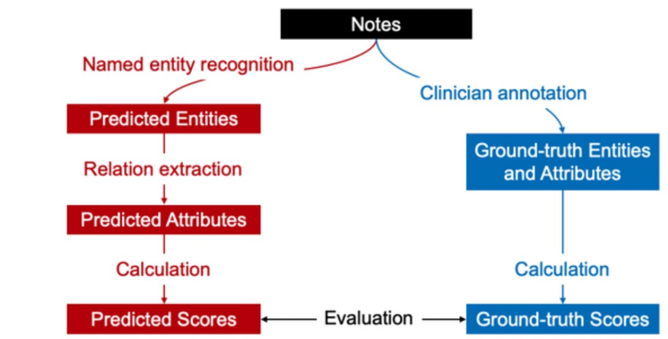
Background

- **Cutaneous lupus erythematous (CLE)** is an autoimmune skin disorder that manifests as inflammatory lesions in photosensitive areas.
- The **Cutaneous Lupus Erythematosus Disease Area and Severity Index (CLASI) score** measures disease activity and damage in CLE patients.
- There has been little work done previously using natural language processing (NLP) in dermatology to assess disease severity.
- **Objective:** To develop a NLP model that interprets physical examination (PE) documentation in CLE patients and computes disease severity scores in the form of CLASI activity and damage scores.

Methods

- Dataset was derived from 50 patients enrolled in the University of Texas Southwestern CLE registry.
  - **Training set:** 89 clinical exams of 24 patients were used to train the NLP model.
  - **Validation set:** 35 clinical exams of 26 patients were used to test the model's accuracy in prediction.
- An entity dictionary was provided rules for labeling vocabulary pertinent to CLASI scores within the PE note, as well as relationships between entities.
- The **BERT** (Bidirectional Encoder Representations from Transformers) **model**
  - Model was trained to predict all entities and relationships in the notes, based on which CLASI scores were calculated.
  - Model was then applied to the validation set. These scores were compared to the ground-truth CLASI scores based on human annotation (**Figure 1**).

Figure 1: Overall workflow



BERT was trained to extract entity and attributes and then calculate scores

Each note was annotated with ground truth entities and attributes. Ground-truth scores (CLASI scores) were provided by a dermatologist (BFC) who performed skin exams and scored patients in-person.

Results

Table 1: Cohort Characteristics

	Training (n = 24)	Validation (n = 26)	P-value
Age*	46.1 (39.5 – 57.5)	46.0 (39.7 – 56.1)	.68
Female	19 (79%)	24 (92%)	.18
Race			
Black	15 (63%)	16 (62%)	.94
Asian	0 (0%)	1 (4%)	.33
Caucasian	8 (33%)	6 (23%)	.42
Baseline CLASI Activity*	5.5 (1.74 – 12.5)	6 (2 – 15.8)	.68
Baseline CLASI Damage*	11 (4.5 – 15)	9.5 (3.5 – 11.8)	.43
Subtype			
DLE	20 (83%)	15 (58%)	<.05
SCLE	3 (13%)	5 (19%)	.52
TLE	1 (4%)	5 (19%)	.10
ACLE	0 (0%)	1 (4%)	.33

*Median of variables taken from the patients' earliest CLE-related visits within the registry

Figure 2: Performance in predicting individual scores

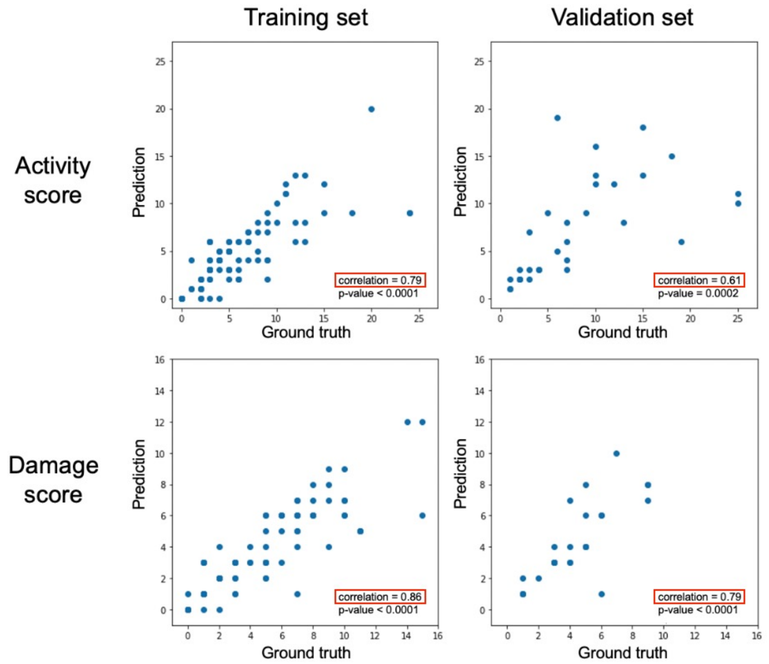


Figure 3: Performance in category prediction accuracy

Activity

Train accuracy: 0.90

Train	Pred mild	Pred severe
True mild	72	9
True severe	0	8

Validation accuracy: 0.90

Validation	Pred mild	Pred severe
True mild	19	2
True severe	1	9

Damage

Train accuracy: 0.87

Train	Pred mild	Pred severe
True mild	53	10
True severe	2	24

Validation accuracy: 0.85

Validation	Pred mild	Pred severe
True mild	17	1
True severe	3	6

Table 2: Performance in predicting score categories

	Accuracy*		Precision*		Recall*		F1*	
	Activity	Damage	Activity	Damage	Activity	Damage	Activity	Damage
Training	0.90	0.87	0.89	0.84	1.0	0.96	0.94	0.90
Validation	0.90	0.85	0.90	0.94	0.95	0.85	0.93	0.89

Discussion

- Our model predicted individual CLASI scores with high precision and recall, with better results on damage; not seen extensively in existing literature
- When predicting score severity categories, our model scored highly for accuracy, recall, precision, and F1 score for both training and validation sets

Limitations

- Single center study
- PE notes from a single clinician
- Notes may be subjective in terms of quality/style
- Newer language models such as GPT may perform stronger

Conclusions

- BERT-based NLP model can be trained to predict CLASI scores in CLE patients using PE notes.
- **Implication:** This study can significantly increase volume of real-world data available for CLE research by efficiently processing EHR
- **Future steps:** We will increase size and representation of the training set to improve accuracy and external validity of BERT's predictions.

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