Doctor Recommendation in Online Health Forums via Expertise Learning

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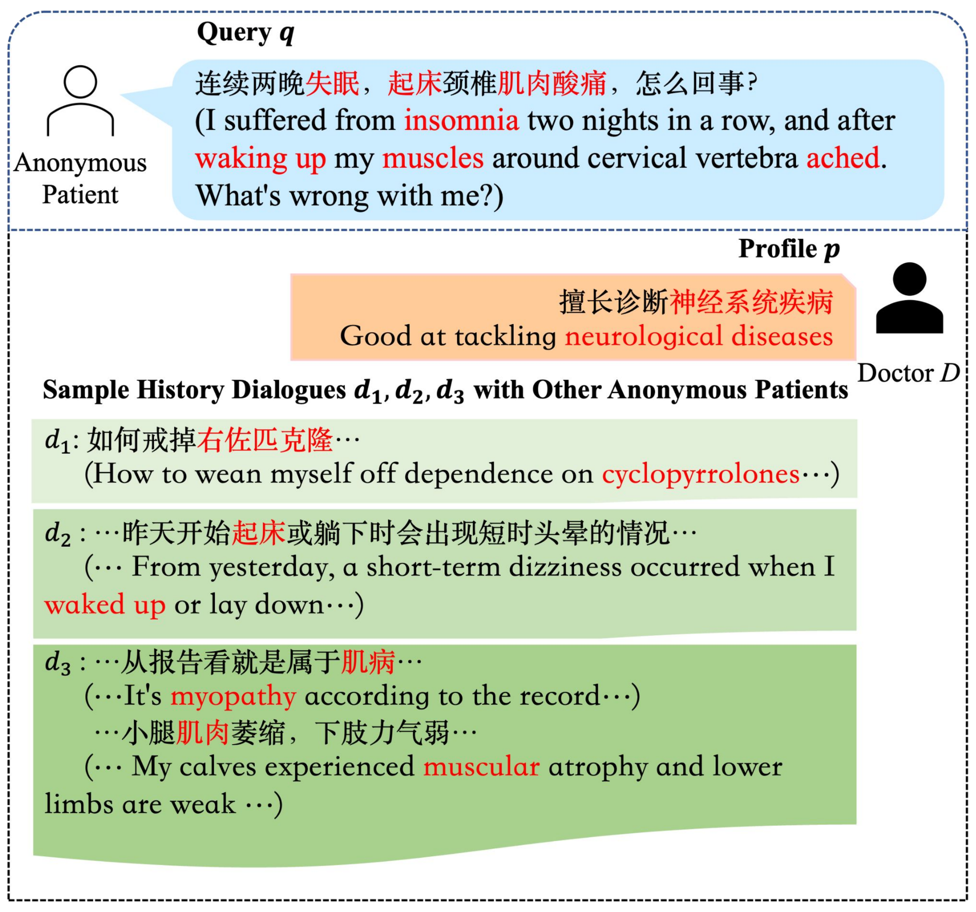
Introduction

- **Motivation**
  - *Massive amounts of patients* go to online health forums for help.
  - *Labor-intensive* to assign doctors manually (common practice).
  - Important to *automate the doctor-patient matching* with NLP.
- **Challenges**
  - Patients' needs should be learned from *a short query*.
  - *Different languages styles* of doctor profiles and patient queries.
- **Contributions**
  - A novel **task** of *doctor recommendation* to learn the matching of a doctor's expertise and a patient's need.
  - A new **dataset** for *doctor expertise learning* through their profiles and past dialogues.
  - Comprehensive **experiments** to investigate the *automatic learning of doctor expertise on the realistic social media data*.



Input:
- A doctor D
  - **Doctor Profile**
  - **History dialogues** with other patients
- A patient P
  - **Patient Query**

Output:
- How likely *D has the expertise to help P*.

Related Work

- **Recommender Systems**
  - Employ *rich user history* to learn their interests (*unavailable* here because of the anonymized patients).
- **NLP for Medical Study**
  - Focus on the understanding of medical text.
  - Limited attempts to *examine expertise learning for doctors*.

Dataset

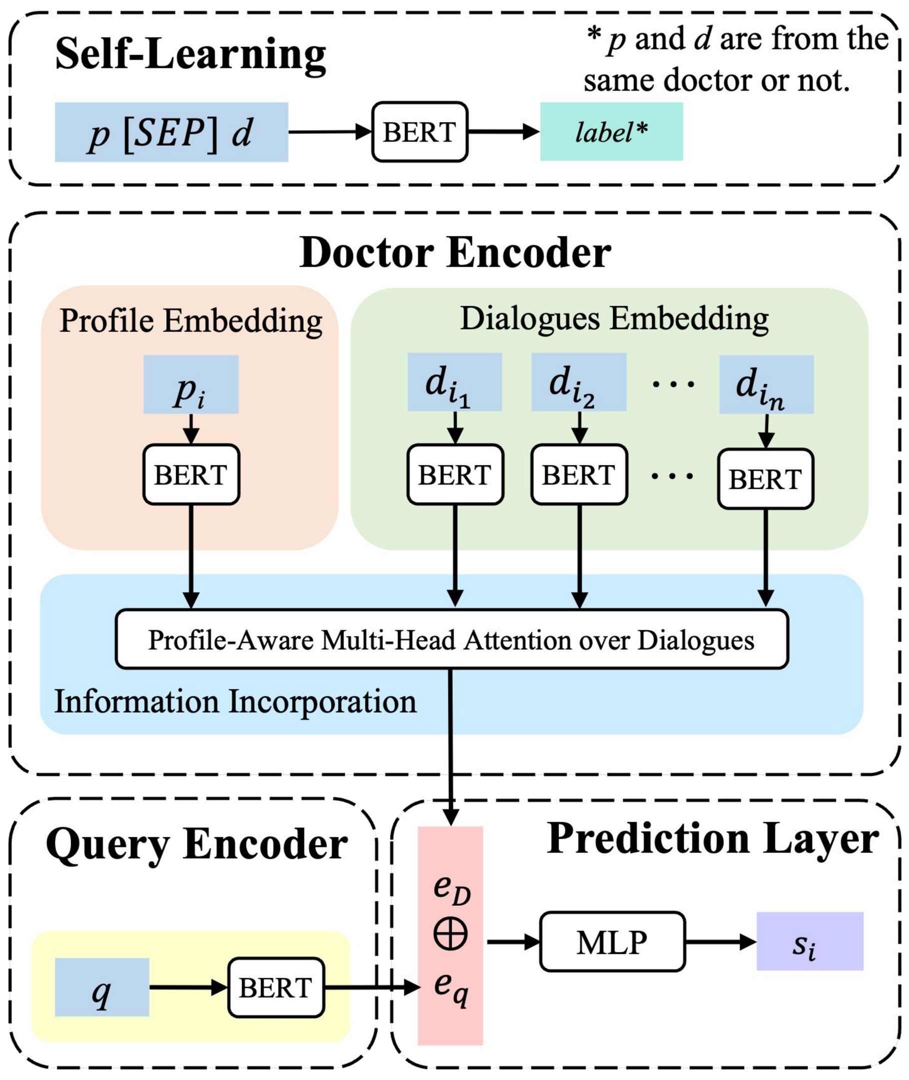
- **Data Statistics**
  - Our dataset collected from Chunyu Yisheng is *large-scale*, *diverse* across different medical departments and contains *rich information*.

# of dialogues	119,128
# of doctors	359
# of departments	14
# of tokens in vocabulary	8,715
Avg. # of dialogues per doctor	332
Avg. # of doctors per department	26
Avg. # of tokens in a query	90
Avg. # of tokens in a dialogue	534
Avg. # of tokens in a profile	88

- **Data Analysis**
  - *86%* of doctors are involved in over 100 dialogues and *84%* dialogues contains over 200 tokens.
  - Doctors use *more professional language* in their profile (30.13% of tokens measured by the THUOCL medical lexicon), while adapting to *layman's language* in conversations (7.83% and 5.52% for patient and doctor turns).

Our Model

- **Self-Learning Task**
  - Fill in the *language styles gap* between profiles and dialogues.
- **Text Encoder**
  - Profiles and queries are encoded *directively* with BERT.
  - Dialogues are treated as a *concatenated chronological turns*.
- **Multi-head Attention**
  - *Incorporate information* from profiles and dialogues into doctor representation.



- **Prediction**
  - Output *expert degree* based on the pair of query embedding and doctor embedding.

Experimental Results

Models	P@1	MAP	ERR@5
Simple Baselines			
Random	0.010	0.052	0.001
Frequency	0.005	0.032	0.001
KNN	0.082	0.151	0.008
Cos-Sim (P+Q)	0.049	0.122	0.005
Cos-Sim (D+Q)	0.056	0.136	0.006
GBDT	0.018	0.052	0.002
Neural Comparisons			
MLP (P+Q)	0.164	0.331	0.018
MLP (D+Q)	0.174	0.341	0.019
MLP (P+D+Q)	0.153	0.312	0.017
DSSM (BERT with D)	0.087	0.182	0.009
DSSM (BERT with P)	0.151	0.231	0.012
Dot-Att	0.219	0.38	0.021
Cat-Att	0.167	0.332	0.018
Our Ablations			
Mul-Att (w/o SL)	0.309	0.319	0.019
Mul-Att (w/o D)	0.198	0.217	0.013
Mul-Att (w/o P)	0.521	0.526	0.033
Mul-Att (full)	**0.616**	**0.620**	**0.039**

Simple models perform poorly for our task.

Attention improves model performance in general.

Self-learning is essential.

Incorporating profiles and dialogues is necessary.

Attention Heads Analysis

Head i	Top 5 Keywords
1	muscle, nerve, convulsion, weakness, atrophy
2	dizziness, nerve, headache, internal medicine, sickness
3	nerve, muscle, ache, strain, massage
4	sleep, anxiety, insomnia, nerve, Dexzopiclone
5	muscle, neck, headache, sickness, cervical vertebrae
6	nerve, muscle, neck, ache, lumbar vertebrae

- Attention heads for Introduction example have *different focuses* (top 5 medical terms attended by each head vary).
- All heads are related to the queried symptom of "insomnia" and "muscle ache" in neurology.

ACL 2022: 60th Annual Meeting of the Association for Computational Linguistics. May 22 - 27, 2022. Dublin, Ireland.