From Reports to Knowledge for Patient Safety Improvement through Advancements in Artificial Intelligence

人工知能を用いた患者安全性向上のための事故報告からの知識抽出

Project Investigator (研究代表者)

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Some Patient Safety Facts – WHO

Patient harm is the 14th leading cause of the global disease burden – 42.7 million adverse events occur in patients during hospitalization (out of 421 million annual hospitalizations in the world)

In high income countries (HIC), **1 in 10 patients is harmed while receiving hospital care**, in which nearly half of these incidents or adverse events are preventable.

Unsafe use of medication harms millions and costs billions of dollars annually, amounting about 1% of global expenditure on health – **medication error is the leading cause of avoidable harm in health care system**

WHO - The Third Global Challenge on Patient Safety

Medication Without Harm

WHO Global Patient Safety Challenge

World Health Organization
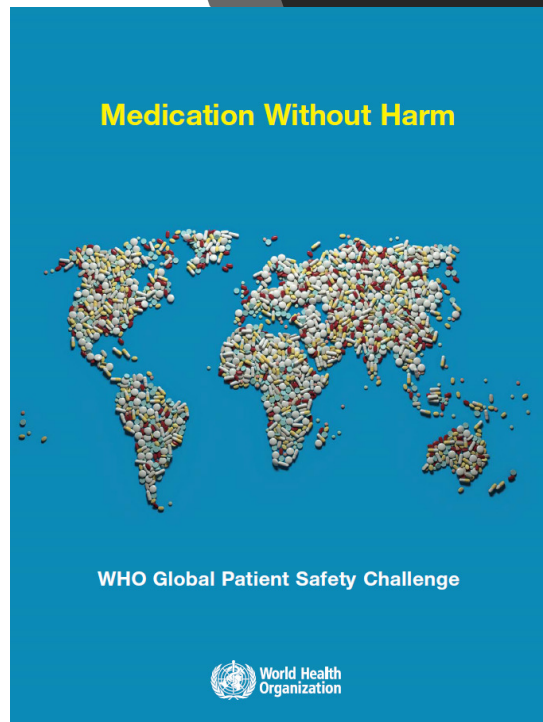
- In March 2017, the **World Health Organization (WHO)** initiated the third Global Challenge on Patient Safety with the thematic priority of "**medication without harm**".

- It is imperative to understand the conditions of high-risk situations which can result in adverse drug events (ADEs).

- Mandatory and voluntary reporting systems have been recommended by the Institute of Medicine and the WHO to capture clinical near-misses and incidents.
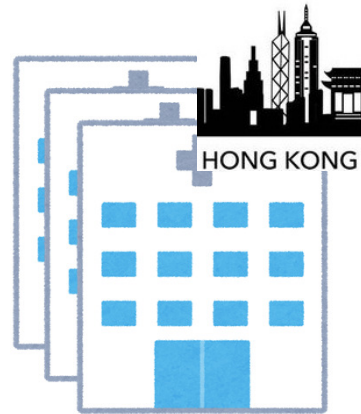
Incident report systems from various countries

NHS England (>9 million reports)
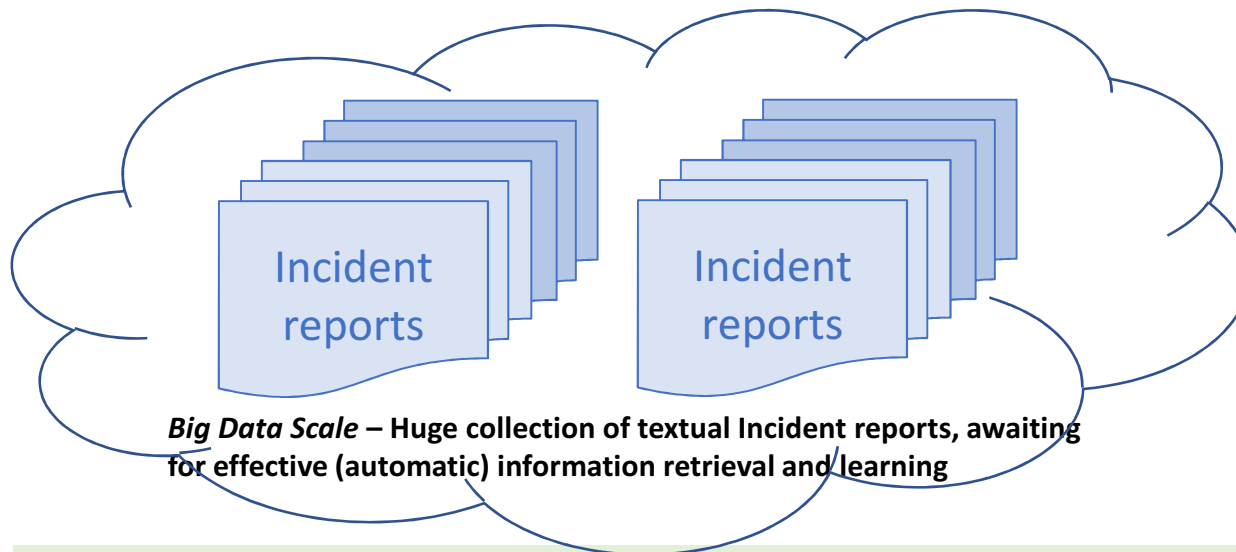
Advanced Incident Management System (AIMS)

Advanced Incident Reporting System (AIRS)

Japan Council for Quality Health Care (JQ) (>7 million reports)

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Incident reports

Incident reports

Big Data Scale – Huge collection of textual Incident reports, awaiting for effective (automatic) information retrieval and learning
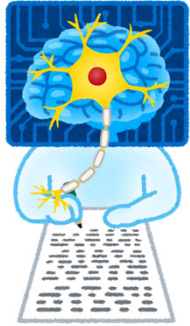
St Luke's International Hospital

Incident report system

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Problem: Unable to identify similar incidents that share the same properties. Time consuming and labor intensive to retrospectively review all cases. Incident reports require a suitable "structure" for effective information retrieval!

Deep learning AI Applications

Article Writer, Machine Translation, Question Answering

Automatic Document Classification

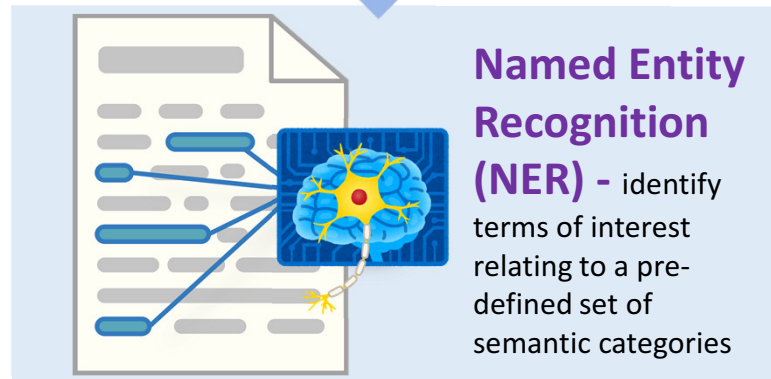Speech Recognition and virtual customer assistant

Pattern Recognition

AlphaGo Zero

Named Entity Recognition (NER) - identify terms of interest relating to a pre-defined set of semantic categories

Data Analytics

Purpose of research

This research attempts **to develop a scalable approach to extract actionable data from unstructured textual reports to facilitate incident learning**

We will develop an **Incident Report Named Entity Recognition System** through recent advances in Artificial Intelligence and examine its performance
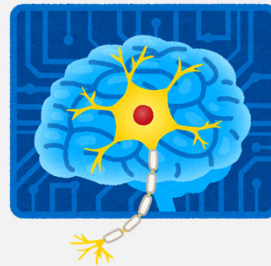
This research will revolutionize the ways how we **collect, retrieve and utilize** incident reports for preventing adverse events and promoting safety in medical care
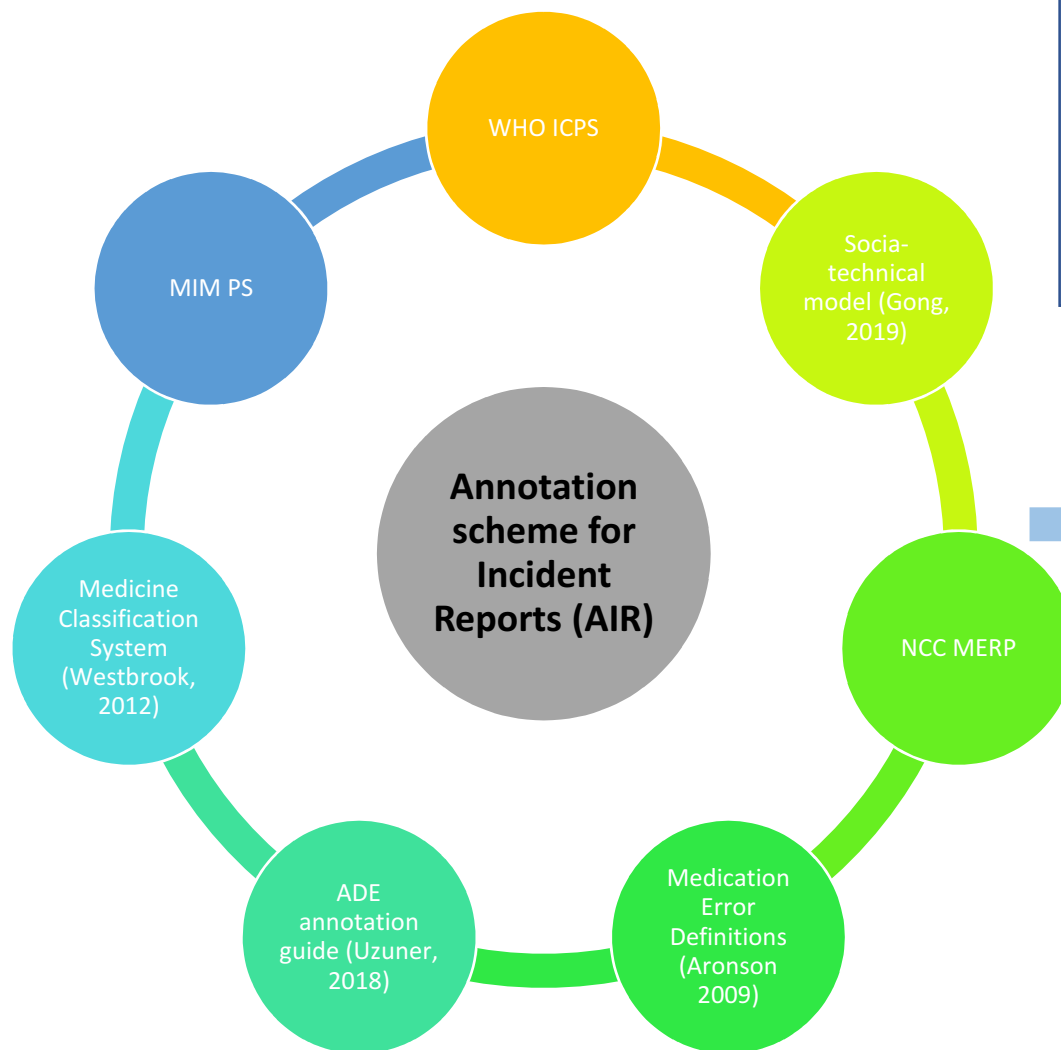
Key Enabling Research

Medication Errors Concepts Development

AI model – Named Entity Recognition via Deep Learning
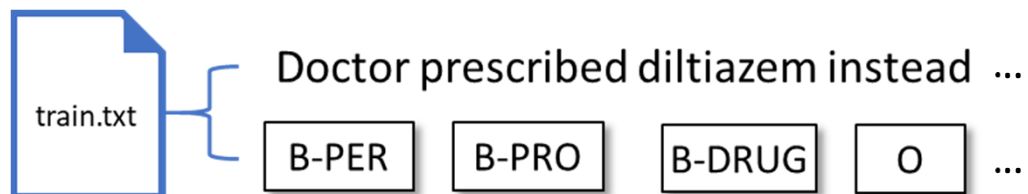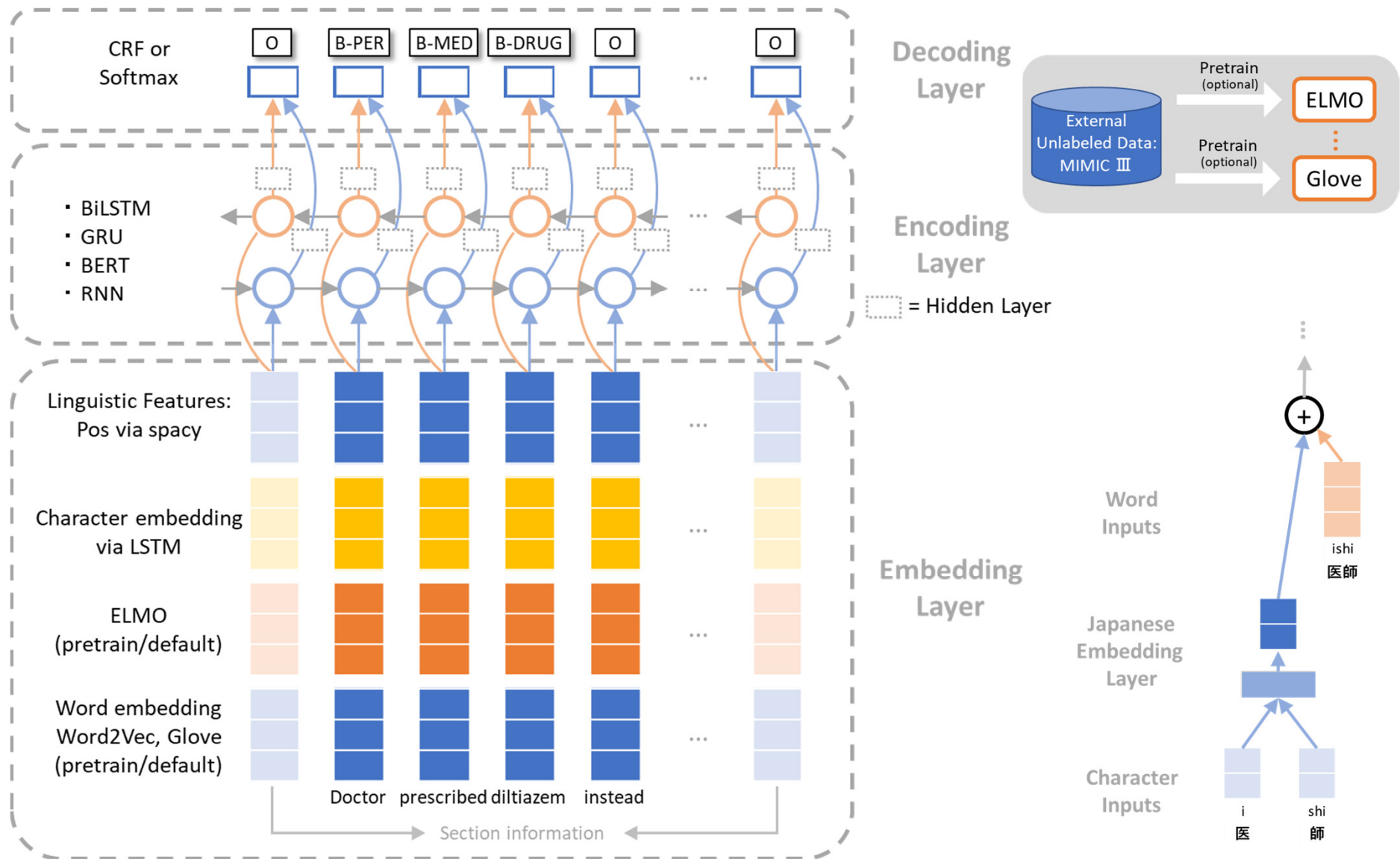
Incident Reporting System Innovation

Create gold standard for training and testing AI model

Annotation scheme for Incident Reports (AIR)

WHO ICPS

Socia-technical model (Gong, 2019)

MIM PS

NCC MERP

Medicine Classification System (Westbrook, 2012)

Medication Error Definitions (Aronson 2009)

ADE annotation guide (Uzuner, 2018)

1. Physician intended to prescribe 2ml of incremin syrup, but prescribed
2. 20ml of incremin syrup instead of 2ml for 2-month-old baby in fact.
3. Physician didn't check the order after prescribing. Pharmacist didn't
4. notice that the dose was wrong on prescription checking and dispensed
5. 20ml of incremin syrup. Patient received 20ml of incremin syrup which was
6. tenfold of planned amount.

8. 医師は 2ヶ月の患者にインクレミンシロップ「2ml」を処方すべきところ、
9. 「2ml」のつもりで、実際には「20ml」と処方し、入力内容を確認しなかった。
10. また、薬剤師は、鑑査で処方量が多いことに気付かず調剤した。
11. そのため、予定した量の10倍量のインクレミンシロップが投与された。

People_involved Stength-related Right_drug Prescribing Age Correct_person Dispensing Administration

Ongoing - Medication Errors Concepts Development

Decoding Layer

CRF or Softmax

O | B-PER | B-MED | B-DRUG | O | ... | O

Encoding Layer

· BiLSTM
· GRU
· BERT
· RNN

⬚ = Hidden Layer

Embedding Layer

Linguistic Features: Pos via spacy

Character embedding via LSTM

ELMO (pretrain/default)

Word embedding Word2Vec, Glove (pretrain/default)

Doctor prescribed diltiazem instead

Section information

External Unlabeled Data: MIMIC Ⅲ

Pretrain (optional) → ELMO

Pretrain (optional) → Glove

Word Inputs

ishi 医師

Japanese Embedding Layer

Character Inputs

i 医   shi 師

train.txt

Doctor prescribed diltiazem instead ...

B-PER | B-PRO | B-DRUG | O | ...

NER Deep Learning Structure

Training and Validation → Testing and Evaluation → Deployment

Investigate AI models to accurately predict medication error concepts (name entities) using the existing incident reports

|	BiLSTM-CRF				BERT-CRF			
Overall accuracy	97.68%	precision 82.97%	recall 77.59%	FB1 80.19%	accuracy 97.61%	precision 91.03%	recall 87.44%	FB1 89.20%
Drug		precision 87.96%	recall 89.11%	FB1 88.53%		precision 94.87%	recall 95.81%	FB1 95.34%
Route		precision 91.01%	recall 78.72%	FB1 84.42%		precision 91.64%	recall 80.04%	FB1 85.45%
Strength		precision 93.30%	recall 91.36%	FB1 92.32%		precision 95.94%	recall 96.55%	FB1 96.24%
Form		precision 87.93%	recall 86.15%	FB1 87.03%		precision 92.43%	recall 82.26%	FB1 87.05%
Dosage		precision 77.42%	recall 75.91%	FB1 76.66%		precision 88.65%	recall 87.82%	FB1 88.24%
Duration		precision 68.75%	recall 66.00%	FB1 67.35%		precision 79.66%	recall 82.46%	FB1 81.03%
Frequency		precision 68.59%	recall 62.24%	FB1 65.26%		precision 87.70%	recall 90.24%	FB1 88.95%
Reason		precision 62.65%	recall 41.60%	FB1 50.00%		precision 62.89%	recall 46.62%	FB1 53.55%
ADE		precision 34.78%	recall 19.51%	FB1 25%		precision 55.32%	recall 34.98%	FB1 42.86%

*Data source: open source gold standard annotated ADEs data from MIMIC III.

Ongoing - Performance evaluation

- Proof of concept - Redefine the ways how we collect, retrieve and utilize incident reports using an AI-suitable framework.

- Externally validate the information retrieval solution for incident reports in other countries, such as Australia, Hong Kong.

- Effective adverse events prevention and promotion of safety in medical care

Expected outcome
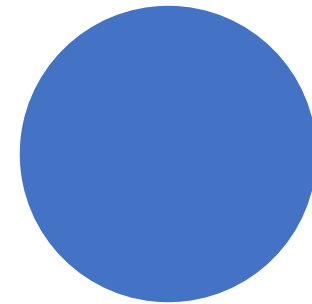
Truly inter-disciplinary research collaboration

- This research involves close collaboration of *multidisciplinary* researchers from health informatics, NLP, AI, information science, pharmacists, physician, nurses, and PS policy makers.

Core research members

Project Investigator (研究代表者)

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Researchers(研究員)

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Research Co-investigators (研究分担者)

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Acknowledgement

Thank you for your attention!
We wish to recruit clinical annotators
to speed up this project!!