Institute of Health
Informatics

UCL

Automated Generation of Hospital Discharge Summaries Using Clinical Guidelines and LLMs

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Motivation

PwC US makes $1 billion investment to expand and scale capabilities in AI

Generative AI

Motivation

Dear SHOs,

There at around 700 discharge letters at PAU waiting to be completed.

Here is how I would appreciate if you can do (and the seniors and nurses would support you)

1. PAU SHO to complete the patients discharged in the last 24 hours or recently. will give you a list. Try to complete these before mid-days.
2. Any doctors to complete discharge summaries for the current patients in PAU ready for discharge – do it as you go along the shifts.
3. For the next 3 weeks, I have allocated one SHO (when we are well-staffed) to do backlog discharge letters. You should do about 60 of the bulk which should take you 3-5 hours depending on the complexity (average 3-5 min per letter).
4. Postnatal long day SHO over the weekend to do backlog discharge letters if not too busy.

Provisional rota as follows:

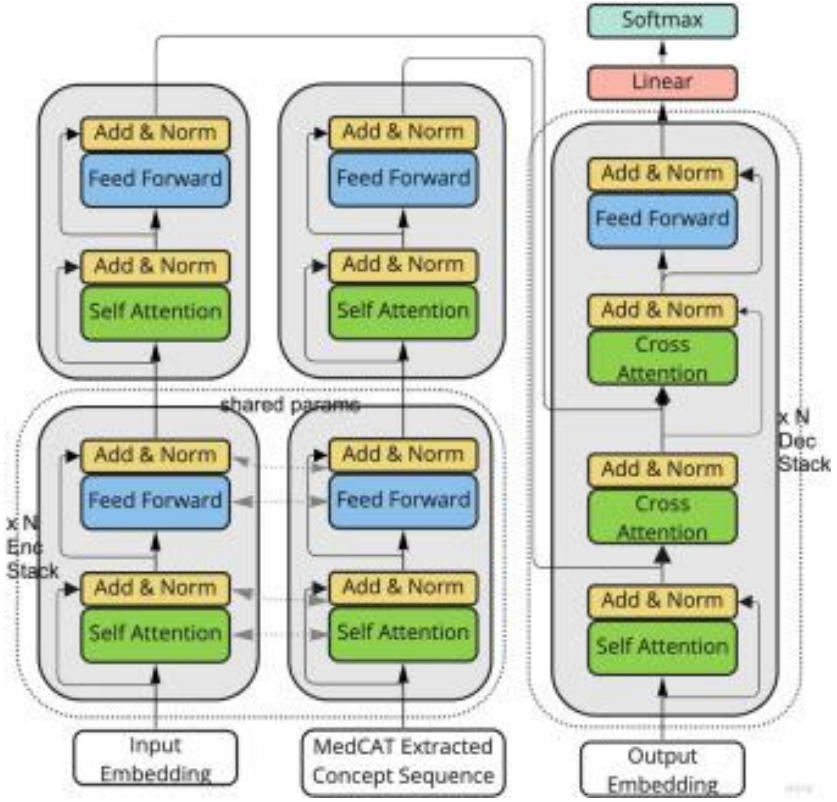
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Date							
SHO							
Date							
SHO							
Date							
SHO							
Date							
SHO							

Motivation

Motivation

Generative Model

Previous Supervised Learning Approaches



Require large diverse paired dataset

Generalizability challenge

Searle, T.; Ibrahim, Z.; Teo, J.; and Dobson, R. J. 2023. Discharge summary hospital course summarisation of inpatient Electronic Health Record text with clinical concept guided deep pre-trained Transformer models. Journal of Biomedical Informatics, 141: 104358.

What goes in a discharge summary?

What goes in a discharge summary?

Clinical guidelines are prompts for doctors

Pros

- Represents best practice
- Explicit fields and description

Cons

- No readily available ground truth dataset

Royal College of Physicians

E-discharge summary example template overview

A Patient demographics:
Patient name
Date of birth
Address
NHS number
Safety alerts

B GP practice:
GP name
GP practice details

C Social context

D Admission details:
Reason for admission
Date/time of admission
Admission method
Relevant past medical, surgical and mental health history

Diagnoses:
Primary diagnosis
Secondary diagnoses

E Clinical summary:
Clinical summary
Procedures
Investigation results

F Discharge details and plan:
Date/time of discharge
Discharge destination
Plan and requested actions
Information and advice given
Patient and carer concerns, expectations and wishes
Next appointment details

Medication:
Added/amended; continued; discontinued
Medication name, form, route
Dose duration description
Dose directions description
Indication/description of amendment
Additional information/patient advice
Quantity supplied
Pharmacy check

G Adverse drug reactions:
Causative agent
Description of reaction

H Person(s) completing record:
Name, role, organisation, date and time

Distribution list:
Name, role, organisation

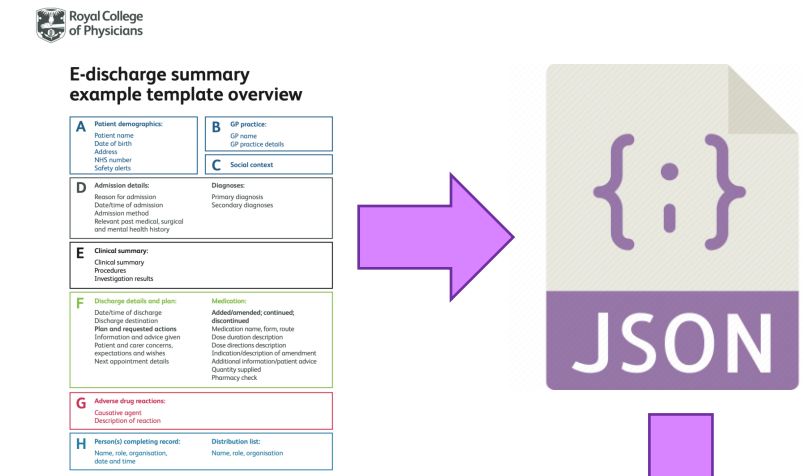
https://www.rcplondon.ac.uk/guidelines-policy/improving-discharge-summaries-learning-resource-materials

Clinical Guidelines -> JSON

Admission details	
Reason for admission*	The main reason why the patient was admitted to hospital, eg chest pain, breathlessness, collapse, etc.
Date/time of admission	Autopopulated
Admission method	May be autopopulated, eg elective/emergency
Relevant past medical, surgical and mental health history	Whilst the GP is likely to hold this information it is useful for documents to stand-alone and provides an insight into the basis for clinical decisions. Includes relevant previous diagnoses, problems and issues, procedures, investigations, specific anaesthesia issues, etc

```
10    "definitions": {
11      "AdmissionDetails": {
12        "type": "object",
13        "properties": {
14          "reason_for_admission": {
15            "description": "The main
                  reason why the patient was
                  admitted to hospital, eg
                  chest pain, breathlessness,
                   collapse, etc. This should
                   be symptoms and not the
                  diagnosis.",
16            "type": "string"
17          },
18          "admission_method": {
19            "description": "Eg elective/
                  emergency",
20            "type": "string"
21          },
22          "relevant_..._history": {
23            "description": "Whilst the GP
                  is likely to hold this
                  information it is useful
                  for documents to stand-
                  alone and provides an
                  insight into the basis for
                  clinical decisions.
                  Includes relevant previous
                  diagnoses, problems and
                  issues, procedures,
                  investigations, specific
                  anaesthesia issues, etc",
24            "type": "array",
25            "items": {
26              "type": "string"
```

Method



Test using:

- Royal College of Physicians guidelines
- 1-shot example
- MIMIC-III physician notes
- GPT-4-turbo (via Azure)

Method

System:
"""You are a consultant doctor tasked with writing a patients discharge summary.
A user will provide you with a list of clinical notes from a hospital stay from which you will write a discharge summary.
Each clinical note has a title of the format [Title]: [timestamp year-month-day hour:min].
Clinical notes are ordered by ascending timestamp.
Only the information in the clinical notes provided by the most recent user message can be used for this task.

The discharge summary must be written in accordance with the following json schema.
{json_schema}
All fields are required.
If the relevant information is not present in the clinical notes, fields can be filled with an empty string or list.
Expand all acronyms to their full terms."""

User:
"""Clinical Notes
{rcp_exemplar_clinican_notes}
Please write a discharge summary only using the information in this message's clinical notes.
The discharge summary must be written in accordance with the json schema given in the system message."""

Assistant:
"""{rcp_exemplar_discharge_summary_json}"""

One-shot example

User:
"""Clinical Notes
{input_clinician_notes}
Please write a discharge summary only using the information in this message's clinical notes.
The discharge summary must be written in accordance with the json schema given in the system message."""

Assistant (excerpt):
"""...
admission_details": {
"reason_for_admission": "Chest tightness pain, breathlessness, nausea and dizziness started at 6 am.",
"admission_method": "Emergency admission via London Ambulance Service",
"relevant_past_medical_and_mental_health_history": [
"Type 2 Diabetes medication (tablets)",
"Hypertension",
"Chronic Obstructive Pulmonary Disease"
]
},...."""

Evaluation

	Percentile			
	25th	50th	75th	Max
De-Duplicated Physician Note Length / Tokens	3107.25	5017.50	8845.25	95682
Output Note Length / Tokens	704.75	793	880.5	1339
Inference Time / secs	33.28	39.44	48.89	125.95
Inference Cost / $	0.10	0.12	0.16	1.04

Table 3: Table of system properties when tested on MIMIC-III notes. The fixed prompt length is 5057 tokens. We calculated token lengths using cl100k_base tokenizer (OpenAI 2021)

Evaluation

11 medical professionals evaluated 53 summaries

4 types of error

- Missing (False Negative)
  - Safety Critical
  - Minor
- Additional (False Positive)
  - Hallucination
  - Irrelevant
- Explanation

- Low inter-annotator agreement 59.72%

Section	Recall	Precision	Acc
Admission Details	0.90	0.95	0.85
Allergies And Adverse Reaction	0.98	1.00	0.98
Clinical Summary	0.76	0.92	0.71
Diagnoses	0.84	0.94	0.80
Discharge Details	0.93	0.96	0.89
Patient Demographics	1.00	0.84	0.84
Plan And Requested Actions	0.90	0.88	0.80
Social Context	0.96	0.88	0.84
Macro Average	0.91	0.92	0.84
Micro Average	0.86	0.92	0.81

Language manipulation vs clinical judgement

E	Clinical summary	
	Clinical summary	Details of the patient's journey can be written in this section, including details about the patient's admission and response to treatments, recorded as a summary narrative. Very concise, where possible.
	Procedures*	The details of any therapeutic or diagnostic procedures performed. This should be the name of the procedure, with additional comments if needed.
	Investigation results	It is important to include results of investigations which the GP is likely to monitor or either of the health condition or assocaiated with medication use eg renal function in patients with diabetes or prescribed an ACE inhibitor. This is also an opportunity to provide more detail on medical problems not related to the main admission eg current lung function tests in patient with COPD admission for elective procedure; cardiac echogram, etc

“include results of investigations which the GP is likely to monitor”

Limitations / Future Work / Rest of PhD!

1. Improved evaluation
    - Data source
    - Improved clinical evaluation framework (low IAA)
    - Automated evaluation for hill climbing + method comparison

2. Data governance-compliant LLM deployed in NHS trust

3. Workflow integration
    - Fail gracefully
    - Human in the loop->automation bias
    - EHR Integration (e.g. structured medication data)

Conclusion

- PoC that LLMs can write valid discharge summaries
- Clinical guidelines make good prompts

Paper

Code

Contact