

PHUSE EU CONNECT 2020, ML07

AI-Assisted Medical Coding

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Thomas Ellebæk, Clinical Data Scientist

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The Project

Aim: Improvement of coding process.

Faster and more consistent coding.

Approach: Rule-based and ML model building (Python).

Focus on adverse events.

Status: Candidate models and an early prototype web application.

Project Team



Dr. Piyush
Srivastava
Medical Coder



Thomas Ellebæk
*Clinical Data
Scientist*



Christian
Christensen
*Statistical
Programmer*



About Medical Coding

Classification ('coding') of reported medical terms into standardised codes.

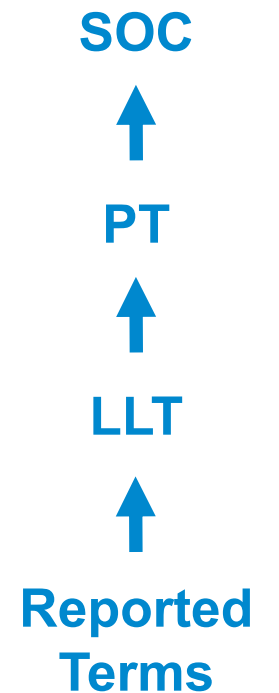
Reported terms are often free-text.

Coding improves:

- Consistency
- Interpretation
- Ability to summarise

Typical domains: Adverse events, medical history and concomitant medication.

Process is often manual.



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REPORTED TERM	LLT
BURNIG AT INJECTION SITE	Injection site burning
HOT INJECTION SITE	Injection site burning
INJECTION SITE PAIN	Injection site pain
TRANSJECTION SITE PAIN (STINGING)	Injection site stinging

Examples of "PT: 'Injection site pain'

SOC



PT



LLT



**Reported
Terms**

Training and Validation Data

- Multiple clinical trials and PV safety data
- 112,586 adverse events
- ~10,000 LLT across ~4,500 PT
- 53,583 (47.6%) direct hits (MedDRA 22.1)

Training and Validation Data

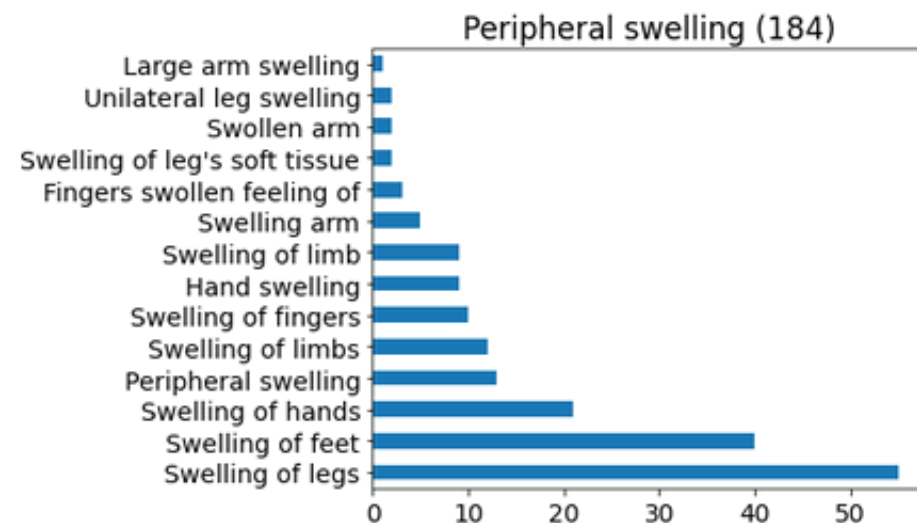
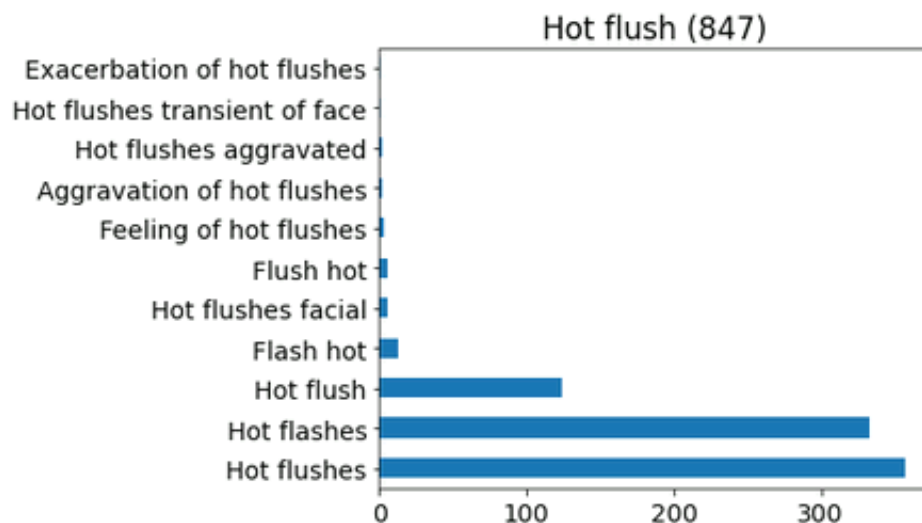
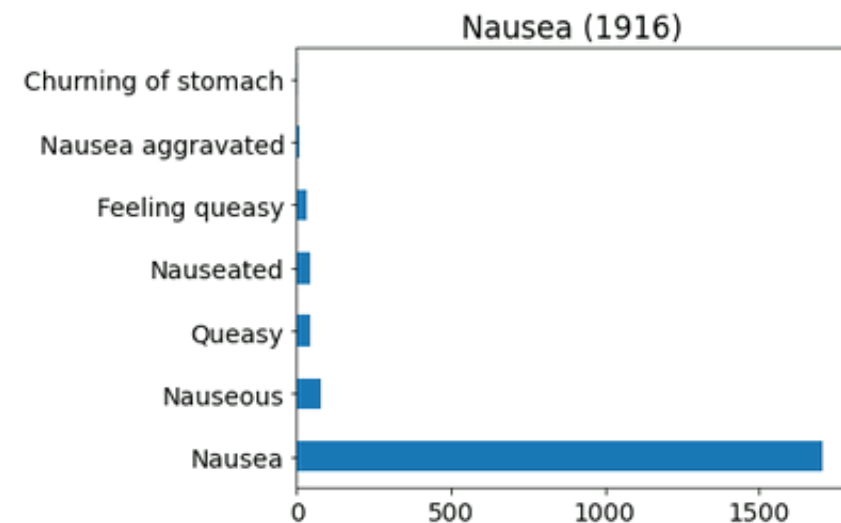
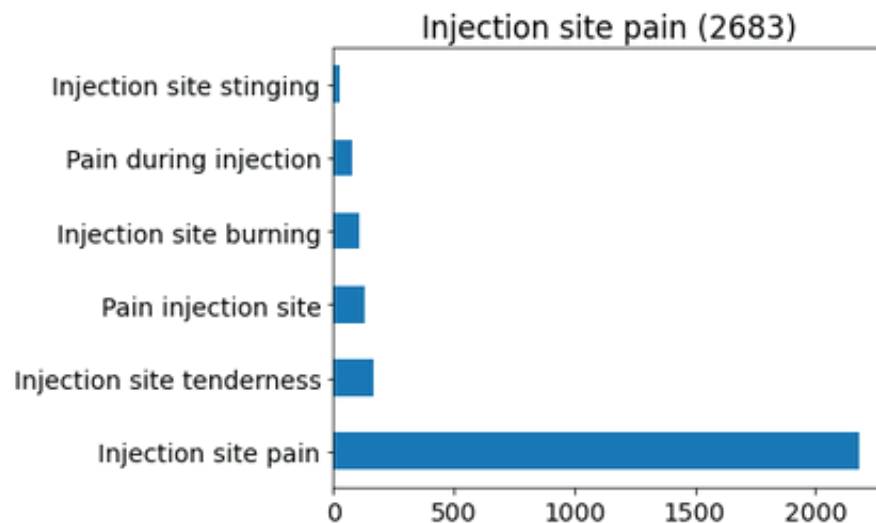
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MedDRA:
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Rule-Based Approach

Classification by string similarity

Reported term: PAIN AT INJECTION SITE

LLTs:

Injection site pain

Pain injection site

Matching reported terms to dictionary LLTs by considering:

- Exact word-matches:

$$\text{Jaccard index}^*: \frac{|A \cap B|}{|A \cup B|} = \frac{3}{4} = 0.75.$$

- Ordering:

Small correction to favour similar ordering.

*A and B are sets of words in the reported term and the LLTs respectively.

Rule-Based Approach

Classification by string similarity

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PAIN AT INJECTON SITE

LLTs:
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Small correction to favour similar ordering.

- Partial word-matches:

Partial score for words one letter apart**.

*A and B are sets of words in the reported term and the LLTs respectively.

**Including insertions, deletions, substitutions and nearest-neighbour swaps (Levenshtein distance of 1).

Rule-Based Approach

Results and discussion

Validation set with 1204 events:

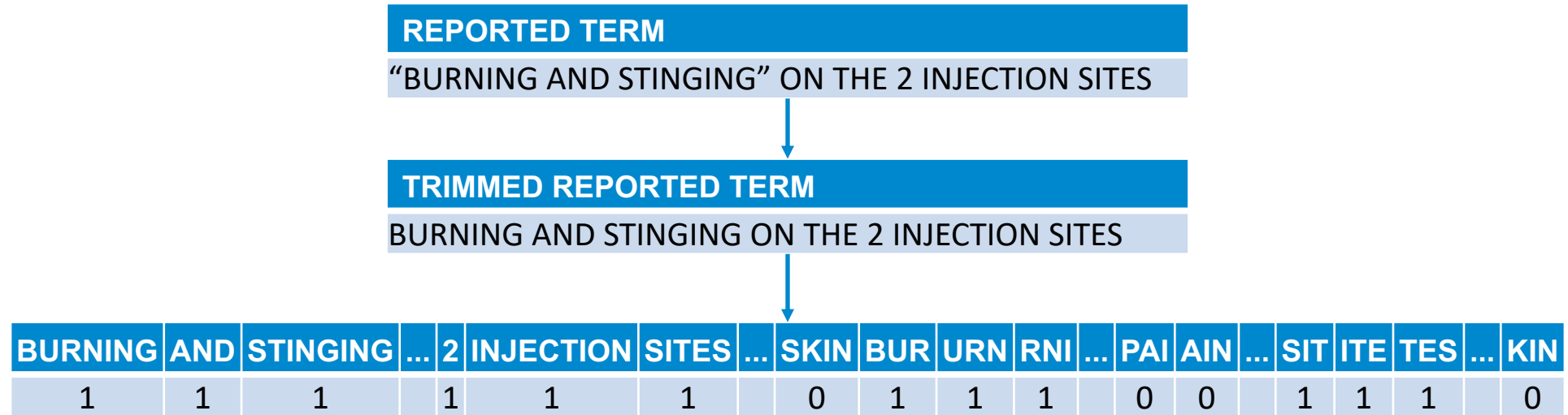
	LLT matches	PT matches	Allowing variations*
Direct matching	592 (49.2%)		
Rule-based LLT	818 (67.9%)	948 (78.7%)	912 (75.7%)

Examples:

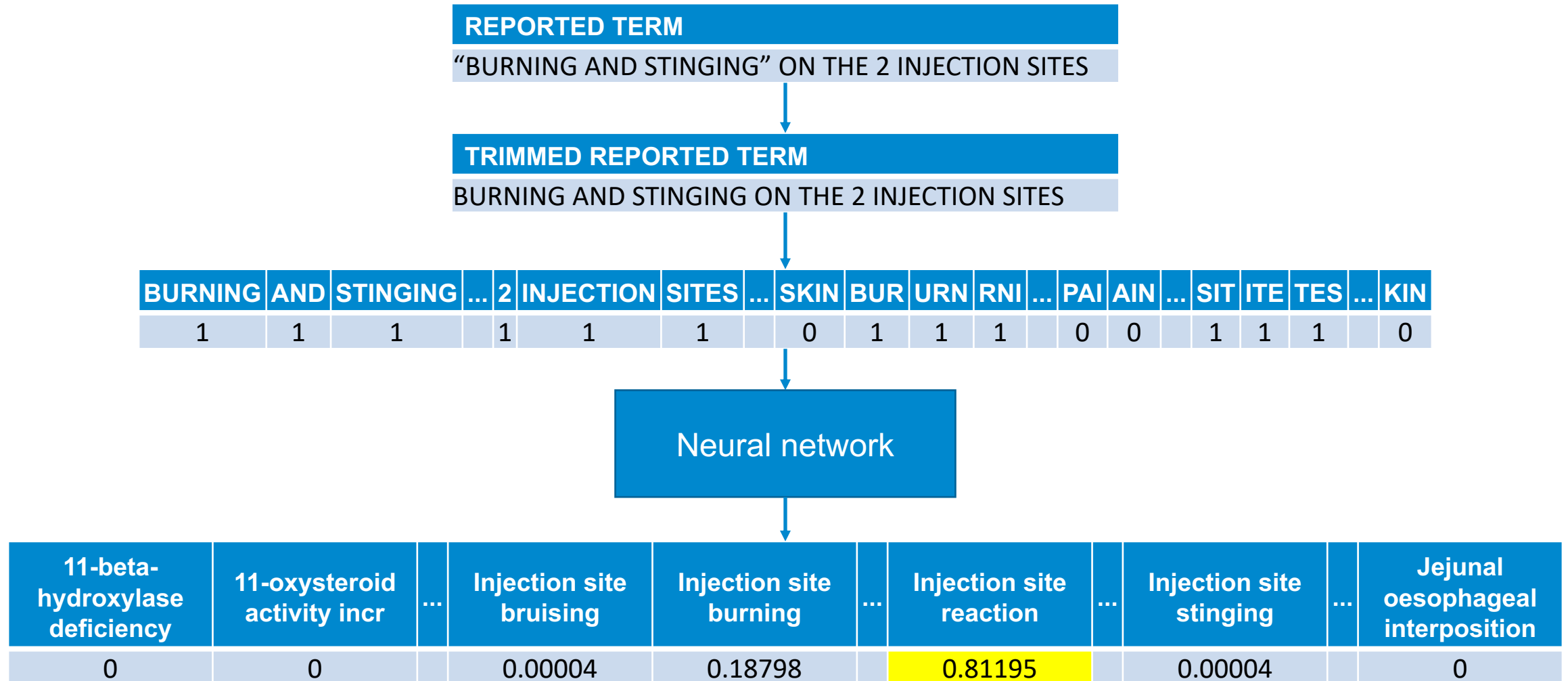
REPORTED TERM	Coded LLT	Model LLT	Comment
PAIN IN THE SITE OF INJECTION	Injection site pain	Pain injection site	Very specific
PAIN SECONDARY TO PNEUMONIA	Pain	Pain in toe	Spelling too flexible
INCREASING PSA	PSA increased	PSA	Spelling not flexible enough
LACK OF APPETITE	Appetite absent	Efficacy, lack of	Synonyms and word prioritization missing.

*Including cases where model predictions are equal to or better than coded LLTs.

ML Approach



ML Approach



ML Validation Results

Validation set with 1204 events

	Matches	Confidence > 0.95
ML LLT model	1022 (84.9%)	816 / 866 (94.2%)
ML PT model	1119 (92.9%)	1014 / 1028 (98.6%)

ML Validation Results

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Mismatch type	Example
Predicting equivalent LLT	"Uric acid blood increased" instead of "Blood uric acid increased"
Focusing on wrong part of reported term	"VAGINAL BLEEDING (UNRELATED TO PREGNANCY)" wrongly matches "Haemorrhage in pregnancy"
No pattern detected for classes with few or no examples	"CHOCOLATE CYST OF RIGHT OVARY" wrongly matches "Cyst ovary" instead of "Ovarian chocolate cyst"

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Considerations:

- Robustness. Model for next MedDRA version is trained from scratch and will display quite different predictions.
- Transparency. Can only indirectly explain model predictions.
- Efficiency. Same synonyms are learned again and again for each class.

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ML LLT model	1022 (84.9%)	816 / 866 (94.2%)	
ML PT model	1119 (92.9%)	1014 / 1028 (98.6%)	
+ LLT rule-based	882 (73.3%)		1009 (83.4%)

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Test Results

Test data:

- Single trial
- New sites
- 899 adverse events
- 196 LLT across 152 PT

	LLT matches	PT matches	Allowing variations*
Direct matching	577 (64.2%)		
ML LLT	701 (78.0%)	771 (85.8%)	
ML PT + ML LLT	720 (80.1%)	811 (90.2%)	805 (89.5%)
Human consistency	782 (87.0%)	852 (94.8%)	799 (88.9%)

*Including cases where model predictions are equal to or better than coded LLTs.

Application

Prototype to Production

MedDRA Assistant - version

22.1

▼

Reported term: "BURNING AND STINGING" ON THE 2 INJECTION SITES

Get model predictions

Selected LLT:

Feedback to model

Predicted LLT	PT	Primary SOC	Confidence
Injection site reaction	Injection site reaction	General disorders and administration site conditions	0.81195
Injection site burning	Injection site pain	General disorders and administration site conditions	0.18798
Injection site stinging	Injection site pain	General disorders and administration site conditions	0.00004
Injection site bruising	Injection site bruising	General disorders and administration site conditions	0.00002
Injection site discomfort	Injection site discomfort	General disorders and administration site conditions	0

Manual LLT search (use && to search for multiple substrings)

burn&&inj

LLT Id	LLT	PT	Primary SOC
10022053	Injection site burning	Injection site pain	General disorders and administration site conditions

Our Learnings

AI-assisted coding is feasible.

Promising results:

- ML outperforms rule-based, but hybrid models also look promising
- ML results comparable to human consistency

Foreseen challenges:

- Tool requires change of habits and processes
- Model management (versioning)
- Tool maintenance

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