

Automated Anesthesiology Current Procedure Terminology (CPT) code assignment using natural language processing and machine learning

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DISCLOSURE: I have no financial relationships with commercial support to disclose.



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Key MPOG members involved:

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Anesthesiology CPT Project

Problem and Opportunity:

- MPOG uses anesthesia and surgical CPT codes for case organization for research studies
- MPOG uses anesthesia and surgical CPT codes for inclusion and exclusion criteria of its quality measures
 - We receive billing data from institutions **delayed by 1-2 months** from the date we receive their EMR data
 - This creates a problem in delivering research data and quality metrics
 - Opportunity to create a system to assign CPT
- **Results:**
 - **Implemented ML and NLP to create an ensemble model for automated predicting anesthesia CPT codes**
 - **>95% accuracy, covering >60% of the data**
 - **99.1% of cases in the Top 3 CPTs**

Natural Language Processing (NLP)

NLP: branch of artificial intelligence that helps computers understand, interpret and manipulate human language.

Utility: Create variables from procedure text

- Physiologic, patient, and procedure features including free text
- spelling correction using edit distance, removal of special characters, word stemming
- n-grams, term frequency inverse document frequency (tf-idf), word2vec

There was a cat, Felix, running in my yard this morning.

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Natural Language Processing (NLP)

Results:

Procedure text is sparse: average word count of approximately 10 words per case.

The **vocabulary size** across all cases: 25098 unique words.

Most individual words were **rare**, occurring in less than 10 cases across both datasets, accounting for 19159 or 76.3% of the vocabulary size.

36,356 cases were identified as **missing procedure text**, representing 0.1% of the data

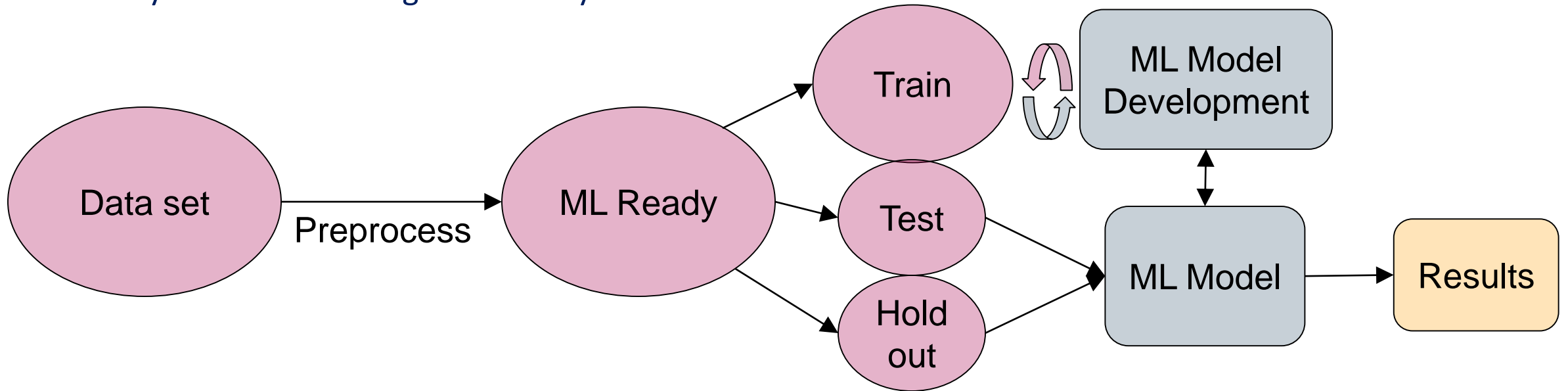
8353 unique **medical misspellings** or 33.3% of the vocabulary size, 21.3% of all cases contained at least one medical misspelling that was corrected

Machine Learning (ML)

Machine learning (ML) is the science of getting computers to act without being explicitly programmed

Can be used to find correlations in (large) data that are difficult for humans to ascertain

Extremely useful tool in large data analytics



Machine Learning (ML)

Results:

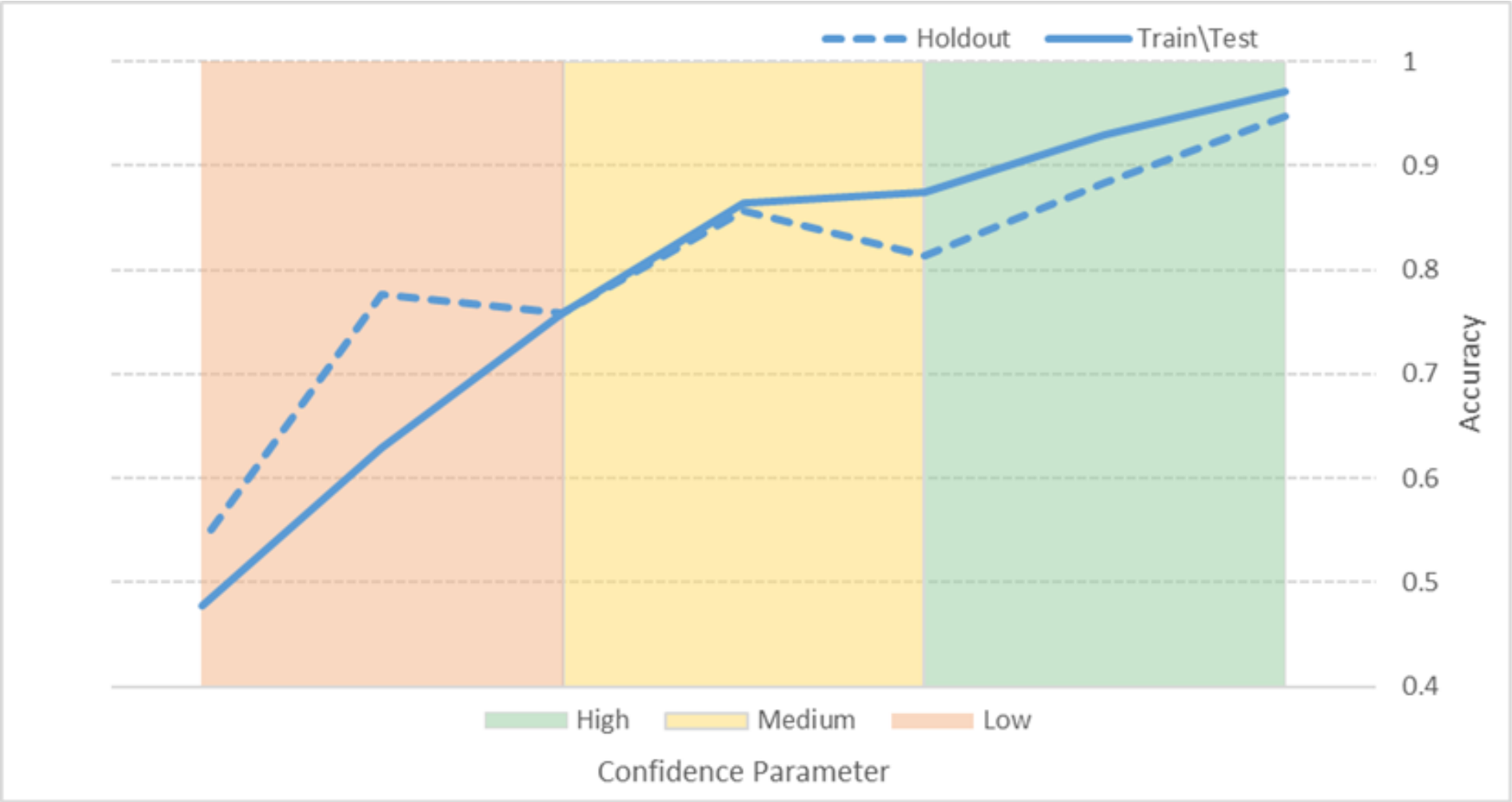
We set out to test several ML models to help determine the correct approach.
We created and evaluated **6 unique ML and deep learning models**

95.2% accuracy, covering 54.8% of data

99.1% cases in the Top 3

Algorithm (CP)	Accuracy (%)	Total Cases (%)
ML4 (CP h1)	97.1	39.3
ML4 (CP h2)	96.4	47.1
ML4 (CP h3)	95.2	54.8

Confidence Parameter



Results – True Holdout Dataset

Holdout: This institution not included in the original dataset

Algorithm (CP)	Accuracy (%)	Total Cases (%)	Algorithm (CP)	Accuracy (%)	Total Cases (%)
ML4 (CP h1)	94.7	48.0	ML7 (CP h1)	96.9	48.3
ML4 (CP h2)	94.1	53.6	ML7 (CP h2)	96.3	52.6
ML4 (CP h3)	93.1	58.0	ML7 (CP h3)	95.0	62.0

ML7 accuracy is 95% while total cases covered is 62.0%

98.6% in the Top 3

The model is generalizable to new data sources

Quality and Research Implementation

- Successfully implemented the CPT prediction tool into research and quality workflows
 - All research projects now have CPT data for existing case data without delay for billing
 - All quality feedback can be conducted as soon as case conclusions

- Both research and quality CPT assignment functions in real time
 - CPT assignment tool can assign **1 million cases in 10 min**
 - Deliver **top 3 and top single choice with tunable (by accuracy) confidence**

- Can this help UM anesthesia billing team?

UM Anesthesiology Billing and Reimbursement

Currently working with the anesthesia billing department

Auditing: there is a 6-month grace period where institutions can resubmit for reimbursement

Internal UM audit:

– **Six CPT internal audit: \$82.5k annual loss in potential revenue**

M1 Data:

–Using only the h1 confidence: 5.4% disagreement (94.6% agreement)

–**Net: -248 (-762) BUW**

M2 Data:

–Using only the h1 confidence: 6.0% disagreement (94.0% agreement)

–**Net: -321 (-740) BUW**

Testing Interface



Anesthesia CPT Evaluation

[Change to Advanced View](#)

[Excel / CSV Import](#)

Show entries at a time

Search:

*Case ID *Procedure Text

Add/Remove

No data available in table

Showing 0 to 0 of 0 entries

[Start Process](#)



Testing Interface – Standard View



Anesthesia CPT Evaluation

[Change to Advanced View](#)

Show entries at a time [Export](#)

Search:

Case ID	Your Procedure Text	CPT1	CPT1 Description	CPT1 Class	Confidence
21	Colonoscopy Polypectomy	00810	Anesthesia for lower intestinal endoscop...	Lower_Abdomen	High
22	RIGHT INGUINAL HERNIA REPAIR	00830	Anesthesia for hernia repairs in lower a...	Lower_Abdomen	Low
23	REPEAT CESAREAN SECTION	01961	Anesthesia for cesarean delivery only	OB	High
24	ENDO-DUODENOSCOPY (EGD)	00740	Anesthesia for upper gastrointestinal en...	Upper_Abdomen	High
25	Arthroplasty Hip Total Replacement Anter...	01214	Anesthesia for open procedures involving...	UpperLeg_noKnee	High
26	ENDOSCOPY; COLONOSCOPY	00810	Anesthesia for lower intestinal endoscop...	Lower_Abdomen	Medium
27	SMH TEE	01922	Anesthesia for non-invasive imaging or r...	Radiology	High
28	Arthroplasty Knee Total Replacement	01402	Anesthesia for open or surgical arthrosco...	Knee_Popliteal	High
29	RIGHT EXTRACORPOREAL SHOCKWAVE LITHOTRIP...	00873	Anesthesia for lithotripsy, extracorpore...	Lower_Abdomen	High
30	LAPIDUS PROCEDURE, Correction of 2nd Toe...	01480	Anesthesia for open procedures on bones ...	LowerLeg_BelowKnee	High

Testing Interface – Advanced View

Change to Standard View

Show 10 entries at a time Export

Search:

Case ID	Your Procedure Text	Your CPT	CPT Match	CPT1	CPT1 Description	CPT1 Class	CPT2	CPT2 Description	CPT2 Class	CPT3	CPT3 Description	CPT3 Class	Confidence
21	Colonoscopy Polypectomy	00810	Yes,1	00810	Anesthesia for lower intestinal endoscop...	Lower_Abdomen	00740	Anesthesia for upper gastrointestinal en...	Upper_Abdomen	00952	Anesthesia for vaginal procedures (inclu...	Perineum	High
22	RIGHT INGUINAL HERNIA REPAIR	00830	Yes,1	00830	Anesthesia for hernia repairs in lower a...	Lower_Abdomen	00840	Anesthesia for intraperitoneal procedure...	Lower_Abdomen	00752	Anesthesia for hernia repairs in upper a...	Upper_Abdomen	Low
23	REPEAT CESAREAN SECTION	01961	Yes,1	01961	Anesthesia for cesarean delivery only	OB	01967	Neuraxial labor analgesia/anesthesia for...	OB	01968	Anes/analg cs deliver add-on	OB	High
24	ENDO-DUODENOSCOPY (EGD)	00740	Yes,1	00740	Anesthesia for upper gastrointestinal en...	Upper_Abdomen	00810	Anesthesia for lower intestinal endoscop...	Lower_Abdomen	00790	Anesthesia for intraperitoneal procedure...	Upper_Abdomen	High
25	Arthroplasty Hip Total Replacement Anter...	01214	Yes,1	01214	Anesthesia for open procedures involving...	UpperLeg_noKnee	01402	Anesthesia for open or surgical arthrosc...	Knee_Popliteal	01210	Anesthesia for open procedures involving...	UpperLeg_noKnee	High
26	ENDOSCOPY; COLONOSCOPY	00810	Yes,1	00810	Anesthesia for lower intestinal endoscop...	Lower_Abdomen	00740	Anesthesia for upper gastrointestinal en...	Upper_Abdomen	00902	Anesthesia for, anorectal procedure	Perineum	Medium
27	SMH TEE	01922	Yes,1	01922	Anesthesia for non-invasive imaging or r...	Radiology	00537	Anesthesia for cardiac electrophysiologi...	Intrathoracic	01926	Anesthesia for therapeutic interventiona...	Radiology	High

CPT	Model	BUV diff	CPT	Model	Audit
1922	562	-13	non-invasive imaging or radiation therapy	heart, pericardial sac, and great vessels of chest; with pump oxygenator, age 1 year or older	Tricuspid Valve Replacements, Aortic Valve Sparring Root
532	670	-9	access to central venous circulation	spine and spinal cord procedures (eg, spinal instrumentation or vascular procedures)	Midline Posterior Thoracic Spinal Fusion
532	866	-6	access to central venous circulation	extraperitoneal procedures in lower abdomen, including urinary tract; adrenalectomy	Adrenalectomy
630	670	-5	lumbar region; not otherwise specified	spine and spinal cord procedures (eg, spinal instrumentation or vascular procedures)	Spinal Fusions
1400	1402	-3	open or surgical arthroscopic procedures on knee joint; not otherwise specified	open or surgical arthroscopic procedures on knee joint; total knee arthroplasty	Total Knee Arthroplasties
400	402	-2	integumentary system on the extremities, anterior trunk and perineum; not otherwise specified	reconstructive procedures on breast (eg, reduction or augmentation mammoplasty, muscle flaps)	Breast Reconstructions
145	142	+2	procedures on eye; vitreoretinal surgery	procedures on eye; lens surgery	Intraocular Lens Implant
140	142	+2	procedures on eye; not otherwise specified	procedures on eye; lens surgery	Phacoemulsification with Intraocular Lens



Conclusions

With this project we have:

- Developed an automated real-time anesthesiology CPT assignment tool
- Used for early billing assignment for research and quality improvement projects in MPOG and ASPIRE
- Accuracy >95% accuracy, covering 60% of the data
- 98.6% of cases in the Top 3 CPTs
- Generalizable model that could be applied to any process using large datasets with text for coding applications

Next Steps:

- Expand methods to additional codes (anesthesia and surgical CPT, ICD 9/10)
- Create a specific interface for auditing as well as an integration into billing workflow

Questions?



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