

Faculty of Health Sciences

#### Improving mortality prediction for intensive care unit patients using text mining techniques

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# Motivation

#### Critical illness severity assesment scores

- they can determine problems early for a better holistic treament of patients and making patient care more cost-effective
- SAPS I-III, APACHE I-IV, SOFA, MPS I-III,...

#### MIMIC III database

- free public-access intensive care unit repository
- widely used for predicting the mortality of ICU patients

### Improving 1-month mortality prediction

additional features from text mining (TM)

### Critical illness severity assesment scores

- Quality of recorded data (determines which score can be calculated)
  - SAPS II (Simplified Acute Physiology Score II)
    - point score (0-163) from 12 routine physiological measurements during the first 24 hours
    - worst values used
    - sum up points final score

Parameter	Value (score)							
HR			<40 (11)	40-69 (2)	70-119 (0)	120-159 (4)	>160 (7)	
SBP			<70 (13)	70-99 (5)	100-199 (0)	>200 (2)		
Temp					<39°C (0)	>39°C (3)		
PaO <sub>2</sub> /FIO <sub>2</sub>	<100 (11)	100-199 (9)	>200 (6)					
UO (ml)		<500 (11)	>500 (4)		>1000 (0)			
S. Urea					<28 (0)	28-83 (6)	>84 (10)	
TLC (10 <sup>3</sup> /cc)				<1 (12)	1-20 (0)	>20 (3)		
к				<3 (3)	3-4.9 (0)	>5 (3)		
Na				<125 (5)	125-144 (0)	>145 (1)		
Bicarb			<15 (6)	15-19 (3)	>20 (0)			
Bil					<4 (0)	4-5.9 (4)	>6 (9)	
GCS	<6 (26)	6-8 (13)	9-10 (7)	11-13 (5)	14-15 (0)			
Age -score <40 → 0 40-59 → 7 60-69 → 12 70-74 → 15 75-79 → 16 ≥80 → 18	Chron Metas Hema AIDS	nic disease: static cancer $\rightarrow 9$ st.malig $\rightarrow 10$ $\rightarrow 17$	Type of a Sched. St Medical – Emer.surg	dmission: $argical \rightarrow 0$ $argical \rightarrow 0$ $argical \rightarrow 8$	JAMA 19	993;270(24):2	957-2963 fept.c	

# MIMIC III database (1)

- 58,976 hospitalizations for 46,520 patients
- ICU of Beth Israel Deaconess Medical Center in Boston between 2001 and 2012
- It includes 26 linked tables via (mostly) patient or hospitalization identification numbers
  - demographics, vital sign measurements, laboratory test results, procedures, medications, caregiver notes, imaging reports,...
- De-identification of dates (each patient's date is randomly shifted, but it is internally consisted for each patient), locations, names,...



# MIMIC III database (2)

Nursing notes contain highly specific information about the patient's dynamic physiological state and eventual outcome, such as :

- detailed and regularly-updated record of the interventions performed,
- medications administered,
- vital signs,
- physical examination findings.

# MIMIC III database (3)

#### Example text from a nursing note

PMtransfer from [\*\*Wardname 185\*\*]\n\nPMH PAF/CAD/HTN/CVA '[\*\*27\*\*]/EF 35-40%/arthritis, hyperlipidemia, hyper\nthryroid\n\nPt. at [\*\*Hospital1 2\*\*] [\*\*Location (un) 186\*\*] admitted for C.P. EKG revealed AF (not new), placed on Lopressor and Amio gtt & converted to NSR. First troponin\n0.96, 2nd .217, CK 90, MB 15. Transferred here for cardiac cath--done this afternoon that revealed 3 VD with blockage--no stents were able to be placed. Cardiology consulted. Transferred here to MICU for gradual decline in sats. Currently on 100% NRB, sat 89-92%. Pt. had no SOB or cardiac sx.\n\nNEURO: AAO x 3. No c/o discomfort--in no acute distress.\n\nRESP: LS CTA Bil. 100% NRB. Current sat 93%. ABG post-cath: ph-7.43\nPO2-53, PCO2 33.\n\nCV: NSR 70's, BP 153/77. No cardiac complaints. Skin W&D. R groin site benign-no hematoma or bleeding. #6 arterial & #8 venous sheath pulled at 1545. +DP/PT by doppler. On NTG gtt 1.116 mcg/kg/min.\n#18, #20 SL RH, #20 LH.\n\nABD: soft, NT, +BS\n\nGU: Lasix 40 mg given post cath with good diuresis. Total 1000cc in cath lab\n\nSOCIAL: Wife very involved and updated and other family members\n\nPLAN: To CT for EP studies tonight, BUN/cr to be drawn prior. Resp. distress possibly R/T fluid, pneumonia or PE.\n

Between [\*\*...\*\*] automatic de-identification

# MIMIC III database (4)

#### Our focus

- patients with CKD diagnosis, that survived at least 24 hours (total of 10,867 nursing notes from 4,381 hospitalizations)
- 59.4 % of patients were male with an average age of 65.6 (SD=15.2) and a 13.4 % mortality rate
- 1-month mortality rate was calculated using date of death either from hospital/social security records

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# MIMIC III database (5)

#### Nursing notes (24 hours)

- first nursing note was taken on average
  7.8 hours after admission
- 85.2 % hospitalizations had at least 2 notes, the second was taken on average 14.7 hours after admission
- 38.1 % hospitalizations had at least 3 notes, the third one taken on average 17.5 hours after admission





# TM processing of nursing notes (1)

- Traditional TM extraction of nursing notes text (stemming, stop words removal) – a total of 51,680 unique unigrams and 363,055 bigrams
- Both frequency and term frequency—inverse document frequency (tf-idf) tables were prepared



# TM processing of nursing notes (2)

Unified Medical Language System (UMLS) mapping via MetaMap

- identifies and normalizes biomedical terminology from the UMLS,
- word sense disambiguation,
- polarity of phrases (negative or positive) via NegEx module,
- uses evaluation metric of UMLS
  Content Unique Identifiers (CUI)
- Frequency and tf-idf tabels were prepared

Example of MetaMap-annotated phrases from part of the sentence "URINE MICROSCOPY"

	Meta Candidates
Score	Matched concept
1000	C0430397: Urine microscopy (Microscopic urinalysis) [Laboratory Procedure]
861	C0026018: Microscopy [Laboratory Procedure]
789	C0205288: Microscopic [Qualitative Concept]
694	C0042036: Urine [Body Substance]
694	C0042037: Urine (In Urine) [Functional Concept]
694	C2963137: Urine (Portion of urine) [Body Substance]
	Meta Mapping
Score	Matched concept
1000	C0430397: Urine microscopy (Microscopic urinalysis) [Laboratory Procedure]

#### Methods

- One of the goals is interpretability and avoidance of over-fitting
- Regularized logistic regression based classifiers (5 models)
- 100 repeated hold-out cross-validation with 80/20 split for each of the 5 predictive models
- Standard evaluation metrics for a binary classifier (AUC, Sensitivity, Specificity, PPV, NPV) and additionally number of features selected

# Results (1)

	AUC	Sensitivity	Specificity	PPV	NPV	Nr. selected features
Baseline (SAPS II)	0.761	0.712	0.687	0.283	0.933	1.0
	[0.757-0.766]	[0.704-0.720]	[0.680-0.695]	[0.277-0.288]	[0.931-0.935]	[1.0-1.0]
Unigrams and bigrams (frequency)	0.782 [0.778-0.786]	0.727 [0.721-0.734]	0.714 [0.707-0.722]	0.306 [0.300-0.313]	0.939 [0.937-0.940]	9.1 [6.6-11.6]
UMLS concept mapping (frequency)	<b>0.791</b> [0.787-0.795]	0.736 [0.728-0.745]	<b>0.716</b> [0.708-0.724]	<b>0.310</b> [0.304-0.316]	0.941 [0.939-0.943]	17.6 [14.8-20.5]
Unigrams and	0.786	0.733	0.712	0.306	0.940	25.1
bigrams (TF-IDF)	[0.782-0.790]	[0.725-0.740]	[0.704-0.720]	[0.300-0.313]	[0.938-0.941]	[21.7-28.6]
UMLS concept	0.789	<b>0.747</b>	0.700	0.302	<b>0.942</b>	35.5
mapping (TF-IDF)	[0.785-0.793]	[0.741-0.754]	[0.692-0.709]	[0.296-0.308]	[0.94-0.943]	[31.0-40.0]



# Results (2)

Grouping commonly selected features:

- General concepts (DNR, SAPS II)
- Family related concepts (family meeting)
- Concepts related to bones (coccyx, heel)
- Medical terms (PICC line, CMO,...)

**Frequency of specific features selected in the UMLS concept mapping (Frequency) experiment** 

	Ν
DNR_(DNRDo_not_resuscitate)_[Finding]	100
Map_(Functional_Map)_[Conceptual_Entity]	100
SAPSII	100
Meeting_(Meetings)_[Health_Care_Activity]	98
Coccyx_(Entire_coccyx)_[Body_Part_Organ_ or_Organ_Component]	93
PICC_line_(Peripherally_inserted_central_ catheter_(physical_object))_[Medical_Device]	86
Anuria_[Disease_or_Syndrome]	85
CMO_(Chronic_multifocal_osteomyelitis)_ [Disease_or_Syndrome]	82
Family_[Family_Group]	70
vascular_(Blood_Vessel)_[Body_Part_Organ_ or_Organ_Component]	51

### Conclusions

- Improvements in predictive performance with the addition of unigrams/bigrams, UMLS CUI-s
- Improvements in interpretability (commonly selected features indicating worsening health situation)
- A possible added value in decision support systems in ICU departments, where data is collected in real-time

# Further development

- Using a shorter (e.g., 6 or 12 hours) period, could be used as "early warning" signal
- Including additional non-text type features (laboratory test results)

# Thank you for your attention!

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