

# Vital DB Dataset

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데이터 사이언스, 임상 빅데이터와 만나다!

Improving Patient Care with Big Data

# Korea Clinical Datathon 2018



# Vital Recorder (2012)

A free software



# IRB (2014)

- IRB: Registry Construction of Intraoperative Vital Signs and Clinical Information for Retrospective Cohort Study in Surgical Patients (H-1408-101-605)
- Written informed consent was waived by IRB
- Clinical trial: clinicaltrials.gov (NCT02914444)

수술 환자에서의 후향적 코호트 연구를 위한  
수술중 생체신호 및 임상정보 레지스트리의  
구축

Registry Construction of Intraoperative Vital  
Signs and Clinical Information for Retro-  
spective Cohort Study in Surgical Patients

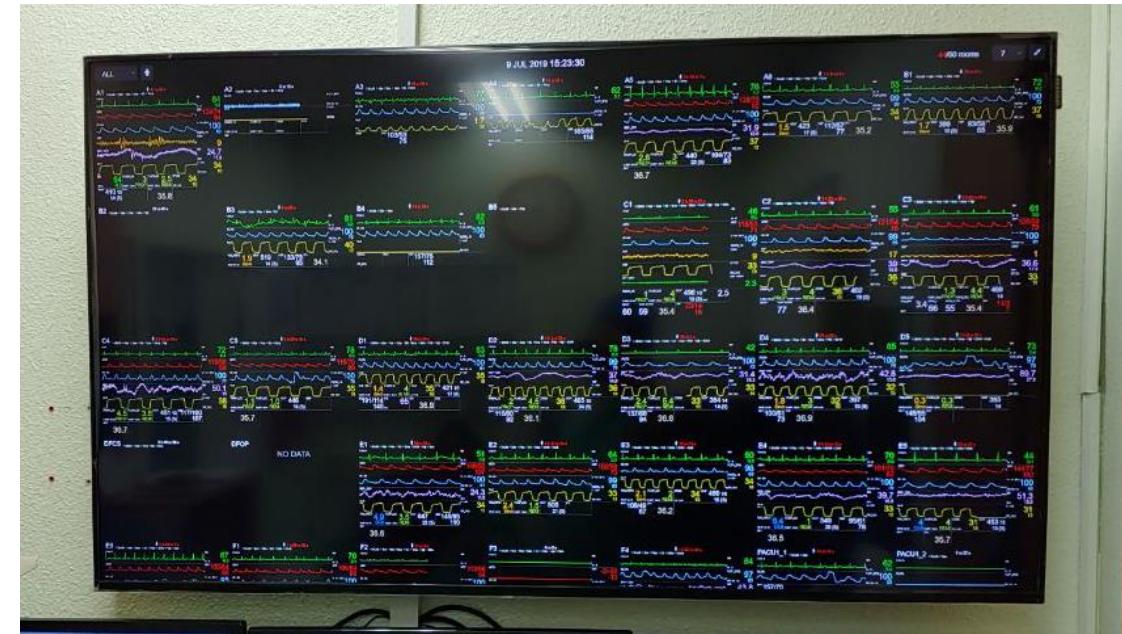
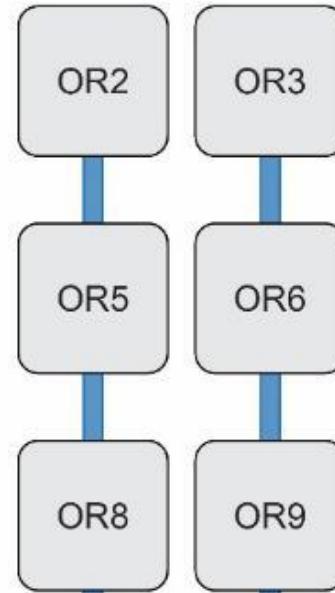


Version No: 1.7

책임연구자 소속: 서울대학교 병원  
책임연구자 이름: 정철우

# VitalDB (2016)

- 6,388 cases -> 42,300 cases
- 2.2 B data points
- 561,150 (average 87, range 13-136) data tracks
- 31 operating rooms in SNUH
- Monthly review
- GS, TS, UR, GY, TPL
- CPR, Table death, Intraop awareness
- adult patient only
- 24/365 recording, 99% coverage





- TRAM NET 4A
- GE Solar 8000 M
- Bispectral Index
- Drager Primus
- EV1000 cardiac monitor

# Online Release

- Online release was allowed by IRB (2014), BRB (2019)
- 모든 수술 시간은 2100년 1월 1일 0시에 시작되는 것으로 이동
- 투약 및 검사 시점 또한 수술 시작 시점에 맞추어 모두 이동
- HIPAA(health insurance portability and accountability act) Privacy Rule 및 국내의 '개인정보 보호법' 및 '생명윤리법'에 의거한 개인 정보 제거를 직접 눈으로 확인
- 데이터 제공 대상자: 본 데이터베이스를 연구 목적으로만 이용하며, 일체의 환자 식별 행위를 하지 할 수 없다는 계약서 체결을 완료한 연구자들에 한정하며, 재배포는 금지

<https://vitaldb.net>

The screenshot displays two views of the VitalDB Data Bank interface. The left view shows a detailed search form with sections for Database, Surgery, Devices & Parameters, and General Characteristics. The right view shows a summary page with a search bar, download statistics, and a detailed breakdown of surgery types and devices.

**Left View (Search Form):**

- Database:** DBID: All, SNUHOR01
- Surgery:** Anesthesia Type: All, General, Spinal, Epidural, Sedation/Analgesia; Op Group: All, GSBP, GSBR, GSCR, GSEC, GSBN, GSHP, GSTP, GSOT, GSUG, GYMN, TSOT, UROT; Op Type: All, open, laparoscopic, robotic; Op Name: All, Use a single space to separate keywords.
- Devices & Parameters:** Device: All, SNUHADC, Solar 8000, Primus, Orchestra, BIS Vista, Vigilite, CardioQ-ODM+, FMS2000, INVOS
- General Characteristics:** Age: All, min, year, MAX; Sex: All, Male, Female; Weight: All, min, kg, MAX; BMI: All, min, MAX.

**Right View (Summary):**

- Data Bank:** Open Access Repository of Vital Signs. Please log in or sign up to use the full data from VitalDB.
- Downloaded: 22 times, 101 cases, 919 tracks
- Database:** ID: Samples (SNUHOR01)
- Surgery:** Anesthesia Type: General, Spinal, Epidural, Sedation/Analgesia (All); Op Group: GSBP, GSBR, GSCR, GSEC, GSBN, GSHP, GSTP, GSOT, GSUG, GYMN, TSOT, UROT (All); Approach: Open, Videoscopic, Robotic; Op Name: Use a single space to separate keywords.
- Devices & Parameters:** Device: SNUHADC, S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14, S15, S16, S17, S18, S19, S20, S21, S22, S23, S24, S25, S26, S27, S28, S29, S30, S31, S32, S33, S34, S35, S36, S37, S38, S39, S40, S41, S42, S43, S44, S45, S46, S47, S48, S49, S50, S51, S52, S53, S54, S55, S56, S57, S58, S59, S60, S61, S62, S63, S64, S65, S66, S67, S68, S69, S70, S71, S72, S73, S74, S75, S76, S77, S78, S79, S80, S81, S82, S83, S84, S85, S86, S87, S88, S89, S8000, Primus, Orchestra, BIS Vista, Vigilite, CardioQ-ODM+, FMS2000, INVOS.

Home / Data Bank

CVI\_WAVE

(TramRac-4A)

 All

Solar 8000M

 All ECG wave (V) [?] HR [?] ST\_V5 [?] MAP (NIBP) [?] ART\_SBP [?] FEM\_DBP [?] PA\_DBP [?] RR (CO2) [?] HR (Pleth) [?] TV [?] Volatile [?] TV (Set) [?] PEEP [?]

## General Characteristics

## Result

ID	Age	Sex	Weight	BMI	Anes
----	-----	-----	--------	-----	------

19	74.0	M	66.2	22.56	
----	------	---	------	-------	--

48	58.0	F	56.2	21.87	
----	------	---	------	-------	--

94	73.0	M	77.2	26.4	
----	------	---	------	------	--

156	63.0	F	59.1	21.84	
-----	------	---	------	-------	--

189	65.0	F	51.3	21.11	
-----	------	---	------	-------	--

Home / Data Bank

help

<input checked="" type="checkbox"/>	6031	75.0	M	61.8	21.71	General	GSBP	Open	Partial
<input checked="" type="checkbox"/>	6039	80.0	F	65.8	27.74	General	GSBP	Open	Pylorus preserving pancreaticoduodenectomy
<input checked="" type="checkbox"/>	6043	70.0	M	82.9	26.64	General	GSBP	Open	Distal pancreatectomy : DP+abdominal
<input checked="" type="checkbox"/>	6053	45.0	F	72.3	27.48	General	GSBP	Open	Excision of
<input checked="" type="checkbox"/>	6061	75.0	M	59.4	20.15	General	GSBP	Open	Pylorus preserving pan
<input checked="" type="checkbox"/>	6107	68.0	M	55.0	20.91	General	GSBP	Open	Distal
<input checked="" type="checkbox"/>	6121	56.0	M	72.5	27.02	General	GSBP	Open	Pylorus preserving
<input checked="" type="checkbox"/>	6257	65.0	F	64.8	30.74	General	GSBP	Open	Whipple
<input checked="" type="checkbox"/>	6262	60.0	F	50.4	21.45	General	GSBP	Open	Distal
<input checked="" type="checkbox"/>	6283	77.0	M	67.7	22.75	General	GSBP	Open	Pylorus preserving
<input checked="" type="checkbox"/>	6284	67.0	F	52.7	24.93	General	GSBP	Open	Partial
<input checked="" type="checkbox"/>	6355	72.0	M	70.3	23.38	General	GSBP	Open	Partial
<input checked="" type="checkbox"/>	6357	52.0	M	92.1	29.43	General	GSBP	Open	Distal pancreatecto
<input checked="" type="checkbox"/>	6368	72.0	M	49.8	21.25	General	GSBP	Open	Pylorus preserving pa

Total: 240 case(s) · 3105.5MB

Download Selected File(s)

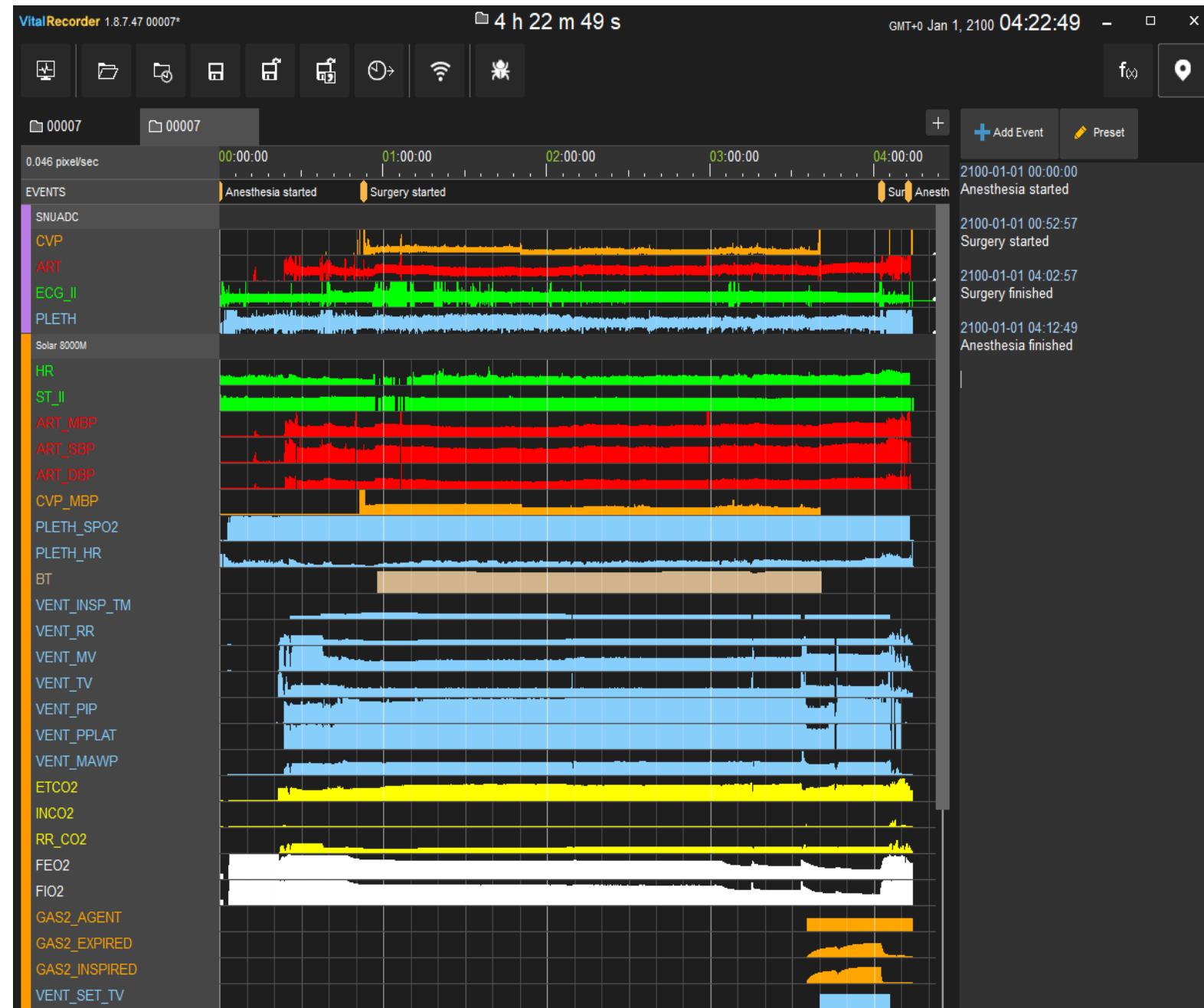
Visitors: Today 56 · Yesterday 62 · Total 11408

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\* This work is supported by the National Research Foundation of Korea (NRF) grant funded by the Korean goverment (MEST) (NRF-2015R1A2A2A01003962).

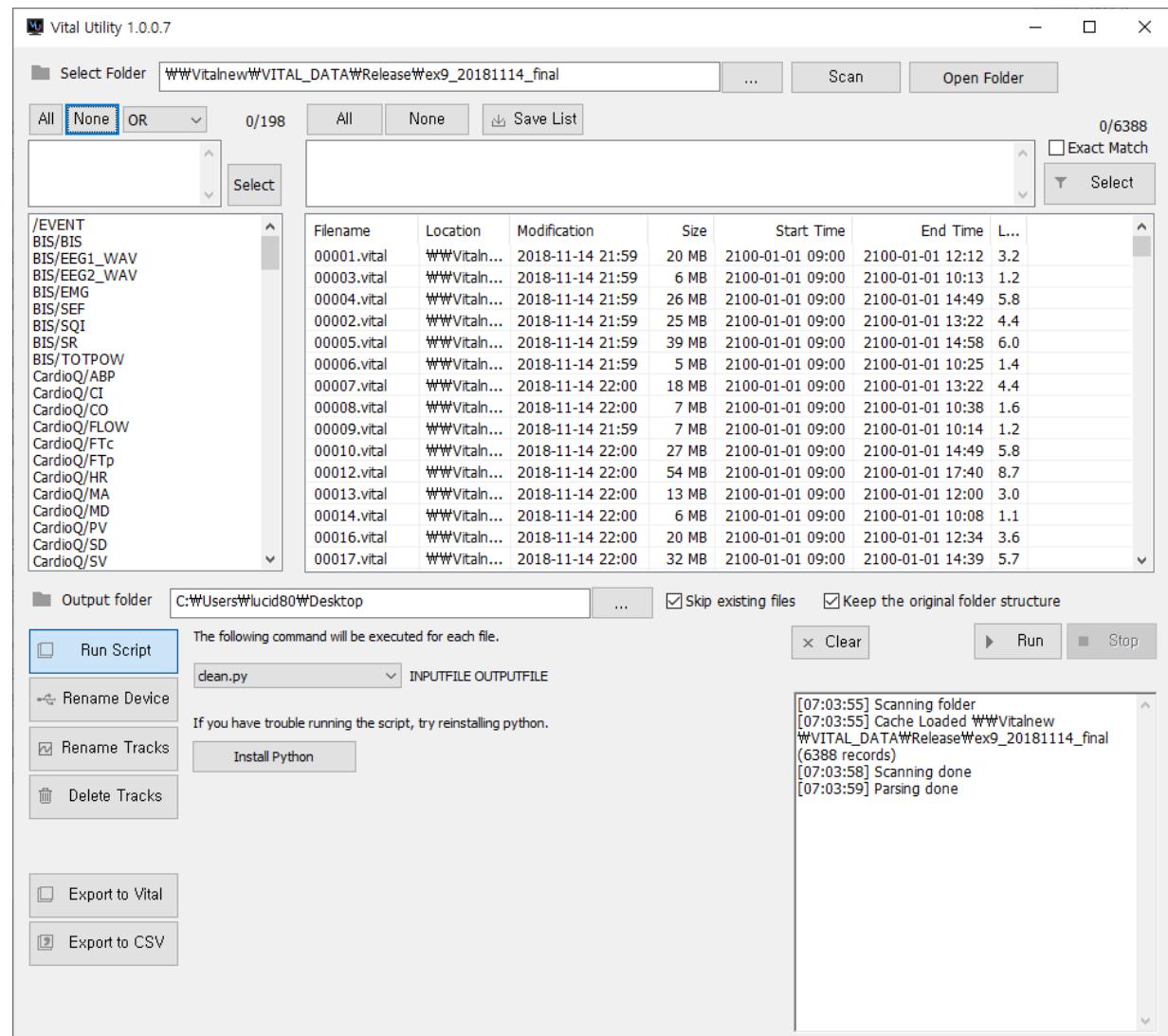
# VitalDB의 사용

VR	00001.vital	2018-08-08 오후...	VITAL 파일	20,829KB
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VR	00003.vital	2018-08-08 오후...	VITAL 파일	6,579KB
VR	00004.vital	2018-08-08 오후...	VITAL 파일	31,500KB
VR	00005.vital	2018-08-08 오후...	VITAL 파일	41,306KB
VR	00006.vital	2018-08-08 오후...	VITAL 파일	6,865KB
VR	00007.vital	2018-08-08 오후...	VITAL 파일	19,291KB
VR	00008.vital	2018-08-08 오후...	VITAL 파일	7,898KB
VR	00009.vital	2018-08-08 오후...	VITAL 파일	7,852KB
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VR	00020.vital	2018-08-08 오후...	VITAL 파일	51,684KB
VR	00021.vital	2018-08-08 오후...	VITAL 파일	17,311KB
VR	00022.vital	2018-08-08 오후...	VITAL 파일	16,281KB
VR	00023.vital	2018-08-08 오후...	VITAL 파일	2,093KB
VR	00024.vital	2018-08-08 오후...	VITAL 파일	11,215KB
VR	00025.vital	2018-08-08 오후...	VITAL 파일	24,231KB
VR	00026.vital	2018-08-08 오후...	VITAL 파일	15,060KB



# 원하는 트랙 데이터의 추출

- Vital Utility
- Command Line
- Shell Script



# 원하는 트랙 데이터의 추출

- Vital Utility
- Command Line
- Shell Script

```
Microsoft Windows [Version 10.0.18362.295]
(c) 2019 Microsoft Corporation. All rights reserved.

C:\Users\lucid80>vital_recs
Usage : vital_recs -OPTIONS INPUT_FILENAME INTERVAL [DNAME/TNAME]

OPTIONS : one or many of the followings. ex) -rl
  a : print absolute time (instead of relative time)
  r : all tracks should be exists
  l : replace blank value with the last value
  h : print header at the first row
  c : print filename at the first column
  n : print the closest value from the start of the time interval as a representative
  m : print mean value as a representative for numeric and wave tracks
  s : skip blank rows

INPUT_FILENAME : vital file name

INTERVAL : time interval of each row in sec. default = 1. ex) 1/100

DEVNAME/TRKNAME : comma seperated device and track name list. ex) BIS/BIS,BIS/SEF
if omitted, all tracks are exported.
```

# 원하는 트랙 데이터의 추출

- Vital Utility
- Command Line
- Shell Script

```
for caseid in caseids:  
    cmd = "vital_recs.exe -rl \"data{:05.0f}.vital\" 10 PPF20_VOL,RFTN20_VOL,PPF20_CE,RFTN20_CE,BIS,SQI".format(caseid)  
    pipe = subprocess.Popen(cmd, stdout=subprocess.PIPE, shell=True)  
    vals = pd.read_csv(io.StringIO(pipe.stdout.read().decode('utf-8')), comment='#').values[:, 1:]
```

# Big Query

Field name	Data type
<u>tid</u>	Int64_t
dt	float
val	float

tid	dt	val
9497070264429038743	4,102,450,450.751	67.08
9497070264429038743	4,102,450,451.751	67.09
9497070264429038743	4,102,450,452.751	67.06
9497070264429038743	4,102,450,453.751	67.09
9497070264429038743	4,102,450,454.751	66.96
9497070264429038743	4,102,450,455.751	66.89
9497070264429038743	4,102,450,456.751	66.86
9497070264429038743	4,102,450,457.751	66.74

# Big Query

Field name	Data type
<b>tid</b>	Int64_t
dt	float
val	float[ ]

tid	dt	val
9497070264429038743	4,102,450,450.751	ARRAY ---
9497070264429038743	4,102,450,451.751	
9497070264429038743	4,102,450,452.751	
9497070264429038743	4,102,450,453.751	
9497070264429038743	4,102,450,454.751	
9497070264429038743	4,102,450,455.751	
9497070264429038743	4,102,450,456.751	
9497070264429038743	4,102,450,457.751	

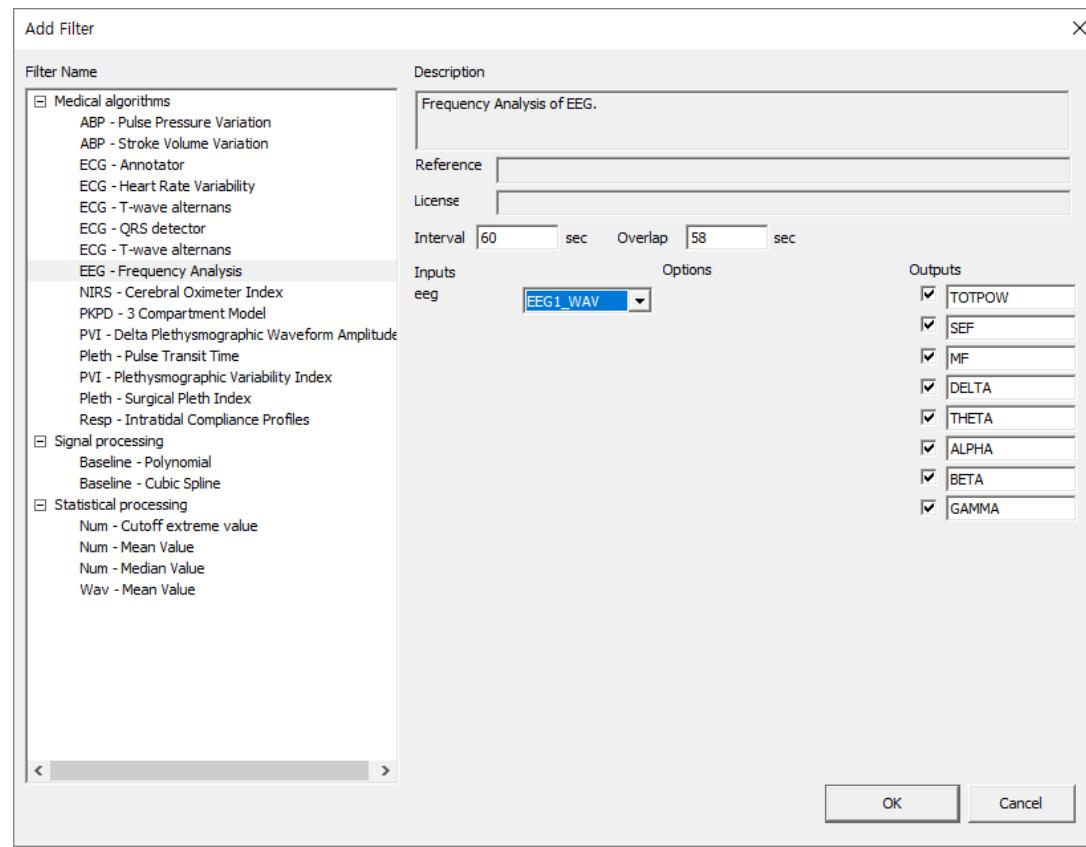
[999999, 999999, 999999, 999999, 35.00001, 35.00004, 35.00004, ... , 34.00002, 33.99999 34.00010, 34.00014]



Array size : Frequency of the equipment  
(128hz, 500hz )

(999999) means NULL value

# Filtering with open source python codes



vitaldb / pyvital

Code Issues Pull requests Projects Wiki Insights Settings

Open source python implementation of medical algorithms

Manage topics

4 commits 1 branch 0 releases 1 contributor

Branch: master New pull request

vitaldb eeg\_fft 추가 Latest commit 83c2e02 an hour ago

README.md Initial commit 2 years ago

abp\_ppv.py 0.2 14 days ago

abp\_svv.py 0.1 a year ago

arr.py 0.2 14 days ago

baseline\_polynomial.py 0.1 a year ago

baseline\_spline.py 0.1 a year ago

ecg\_annotation.py 0.1 a year ago

ecg\_hrv.py 0.2 14 days ago

ecg\_mtwa.py 0.2 14 days ago

ecg\_qrs\_detector.py 0.1 a year ago

ecg\_twa.py 0.1 a year ago

eeg\_fft.py eeg\_fft 추가 an hour ago

nirs\_cox.py 0.2 14 days ago

num\_cutoff.py 0.2 14 days ago

num\_mean.py 0.2 14 days ago

## select data from ART

### Input1 (ART: wave)

- caseid: 355
- tid: 6157862139790434432
- tname: SNUADC/ART
- dt: 4102445075(이상)~4102445200(미만)
- 음수, 1미만, 140초과의 결과를 가지는 범위를 제외하고 VENT\_RR이 측정된 시간과 가급적 가까운 범위를 잡았음

### Input2 (VENT\_RR: num)

- caseid: 355
- tid: 23767158885258774
- tname: Solar8000/VENT\_RR
- VENT\_RR값이 0이 아니고, 정상 범위에 근접한 결과를 가진 환자 선택

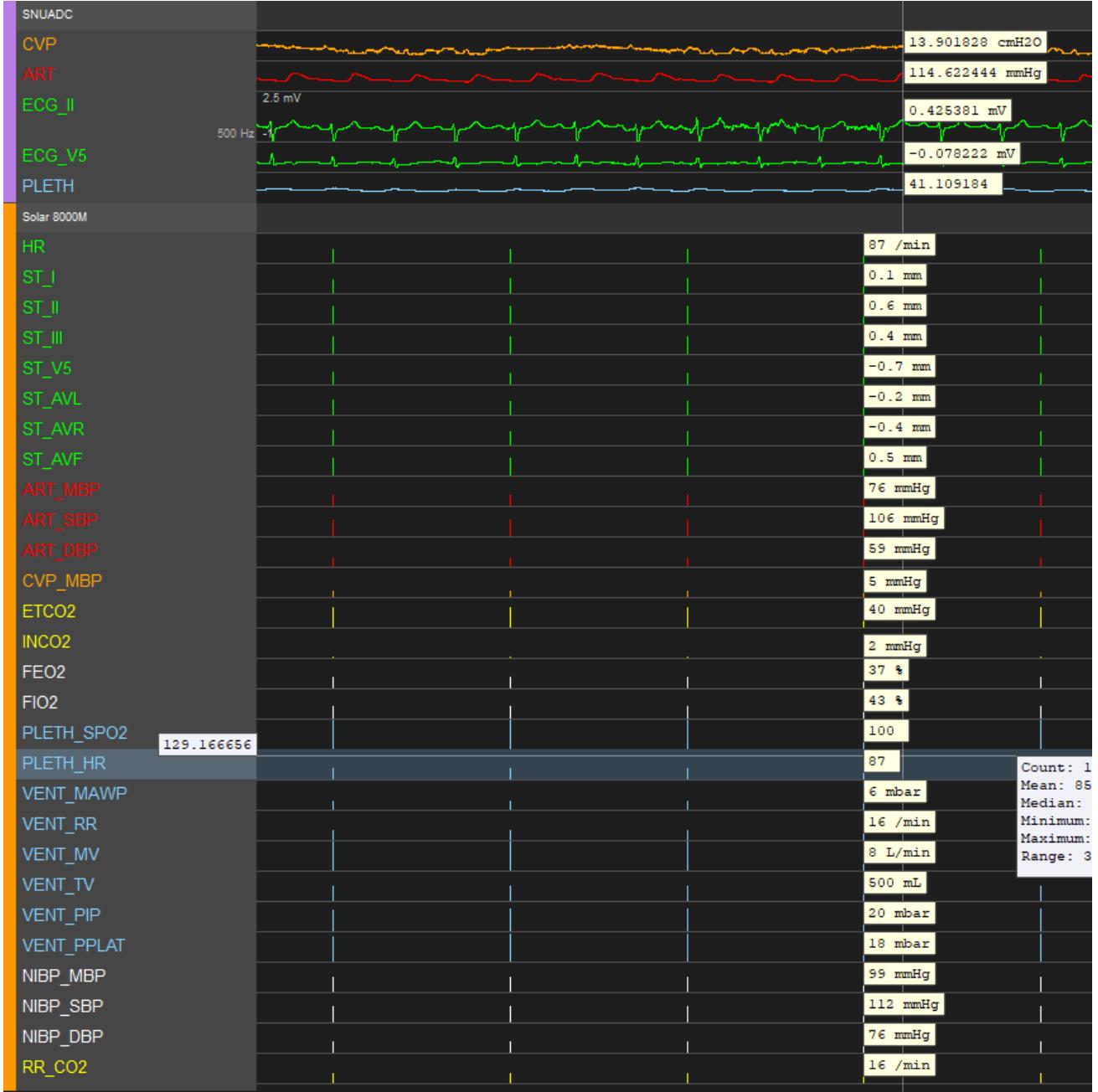
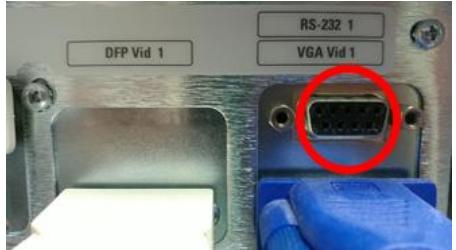
```
querry = 'select * from v_waves where tid = 6157862139790434432 and dt>=4102445075 and dt<4102445200'
x = cursor.execute(querry)
result1 = cursor.fetchall() # art wave

querry = "select * from v_numerics where tid=23767158885258774 and dt>=4102445075 and dt<4102445200"
x = cursor.execute(querry)
result2 = cursor.fetchall() #vent_rr num

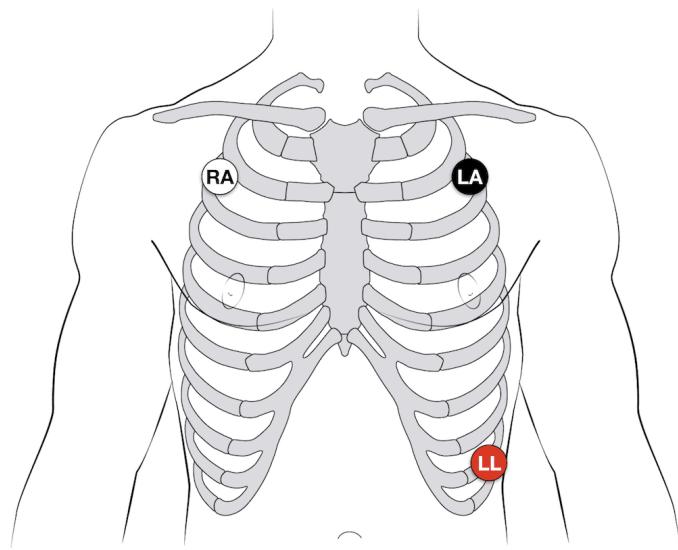
wave=[]
for i in result1[:40]:
    k = [float(x) for x in i['val'].split(',')]
    wave=wave+k
```

# VitalDB 내용

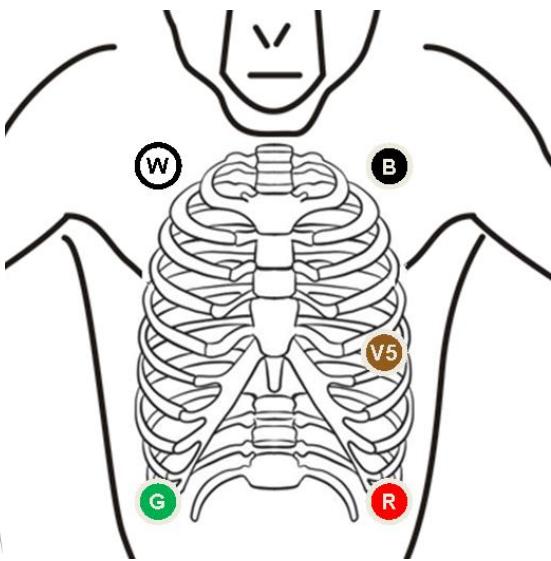
Device	Device type	Company	Parameters	Acquisition interval (sec)	Data type	Number of parameters	Number of Cases
TramRac-4A*	Patient monitor	GE healthcare	ECG, capnography, plethysmogram, respiration, blood pressures	500 Hz	wave	7	6,355 (99%)
Solar 8000M	Patient monitor	GE healthcare	Heart rate, blood pressures, oxygen saturation, temperature, gas concentrations, etc.	2	numeric	45	6,388 (100%)
Primus	Anesthesia machine	Drager	Gas concentrations, volumes and flows, airway pressures	1/62.5 for waves, 7 for numeric values	wave and numeric	42	6,362 (100%)
BIS Vista	EEG monitor	Covidien	EEG waves, BIS and related parameters	128 Hz for EEG wave, 1 for numeric values	wave and numeric	8	5,566 (87%)
Orchestra®	Target-controlled infusion pump	Fresenius Kabi	Target, plasma and effect-site concentrations; infused, residual, total volumes, infusion rate and pressure; drug name and concentration	1	numeric	18	4,927 (77%)
Vigileo	Cardiac output monitors	Edwards Lifesciences	Stroke volume and derived parameters	2	numeric	5	348 (5%)
EV1000	Cardiac output monitors	Edwards Lifesciences	Stroke volume and derived parameters	2		9	599 (9%)
Vigilance II	Cardiac output monitors	Edwards Lifesciences	Cardiac output and derived parameters, temperature, oxygen saturation,	2		16	64 (1%)
CardioQ-ODM+	Cardiac output monitors	Deltex	Stroke volume, cardiac output and related parameters	1/180 for flow and arterial pressure waves; 1 for numeric values	wave and numeric	13	29 (0%)
INVOS	Cerebral/somatic oximeter	Covidien	Cerebral oxygen saturation	5	numeric	2	33 (1%)
Belmont Rapid Infuser	Rapid infusion system	Belmont Instrument	Infused volume, infusion rate, temperatures, pressure	every 2.875 mL infused	numeric	7	15 (0%)



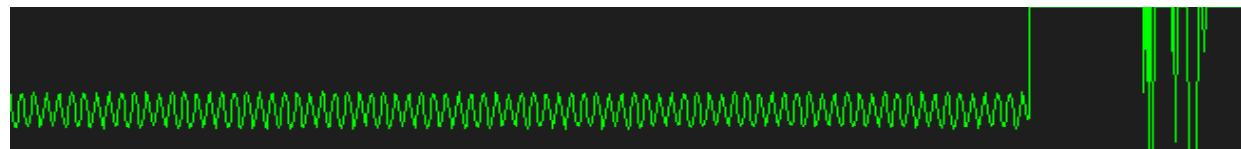
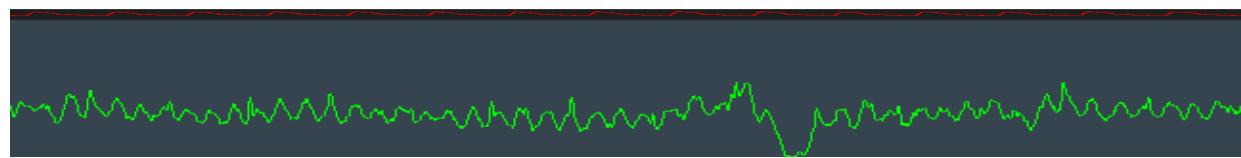
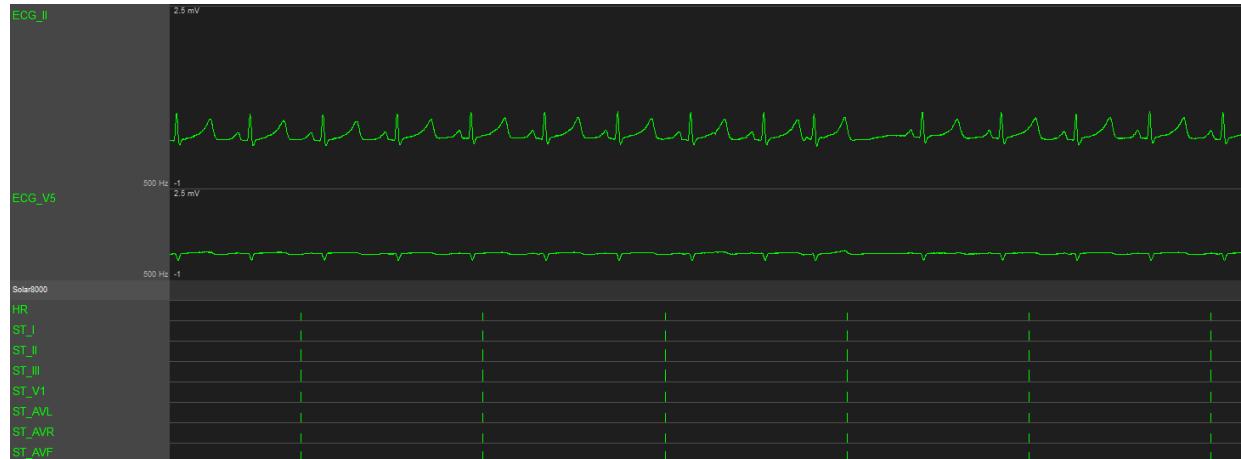
# 심전도



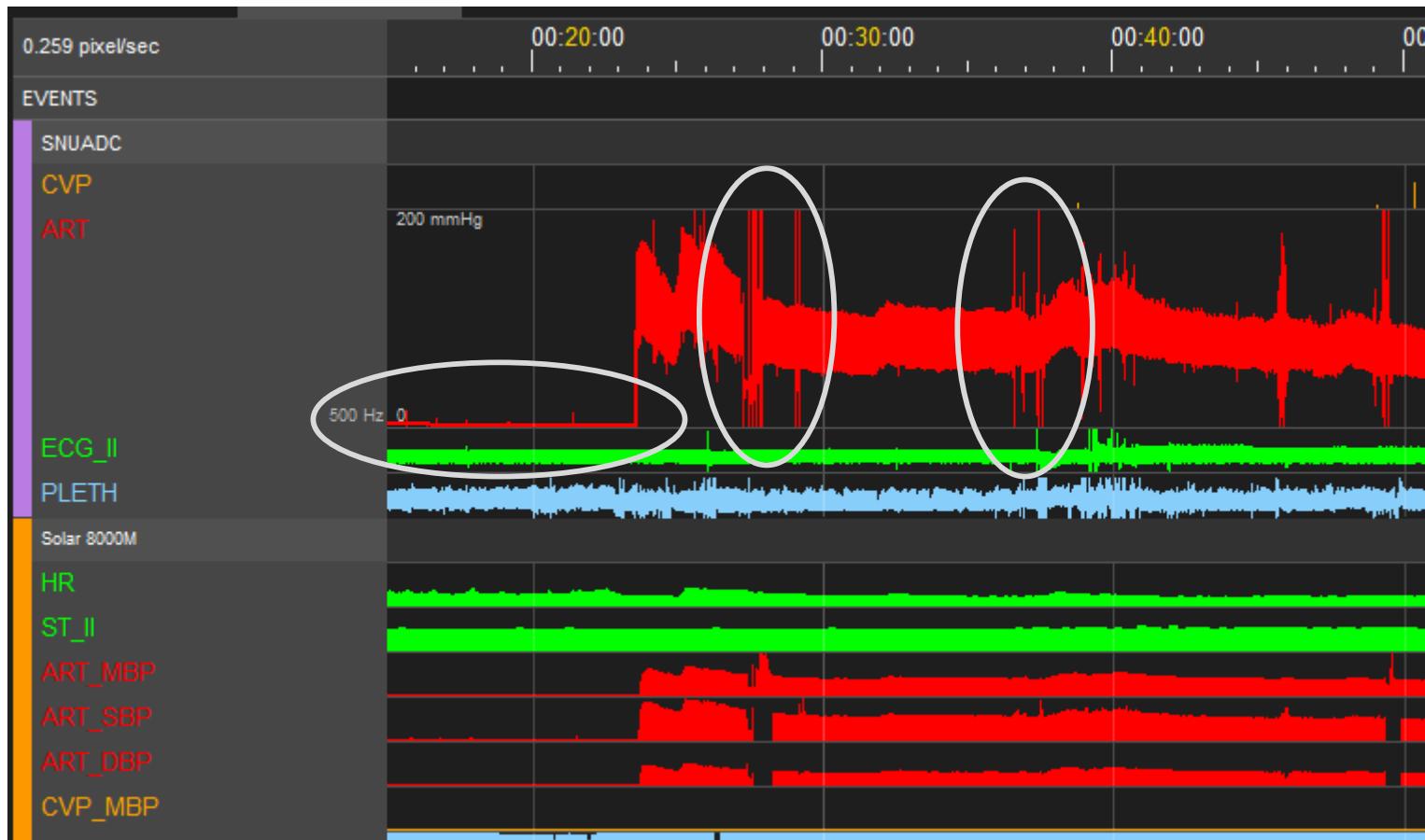
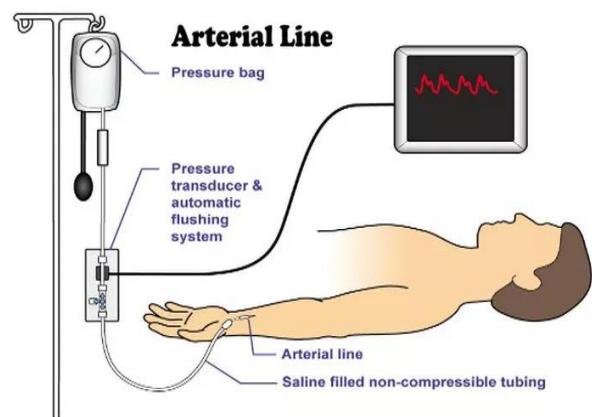
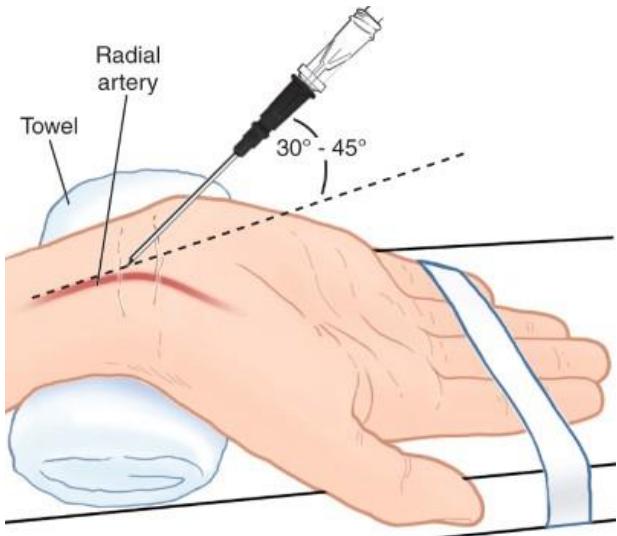
wave: II  
ST: II



wave: II, V5  
ST: I, II, III, V5  
AVL, AVR, AVF



# 혈압 데이터



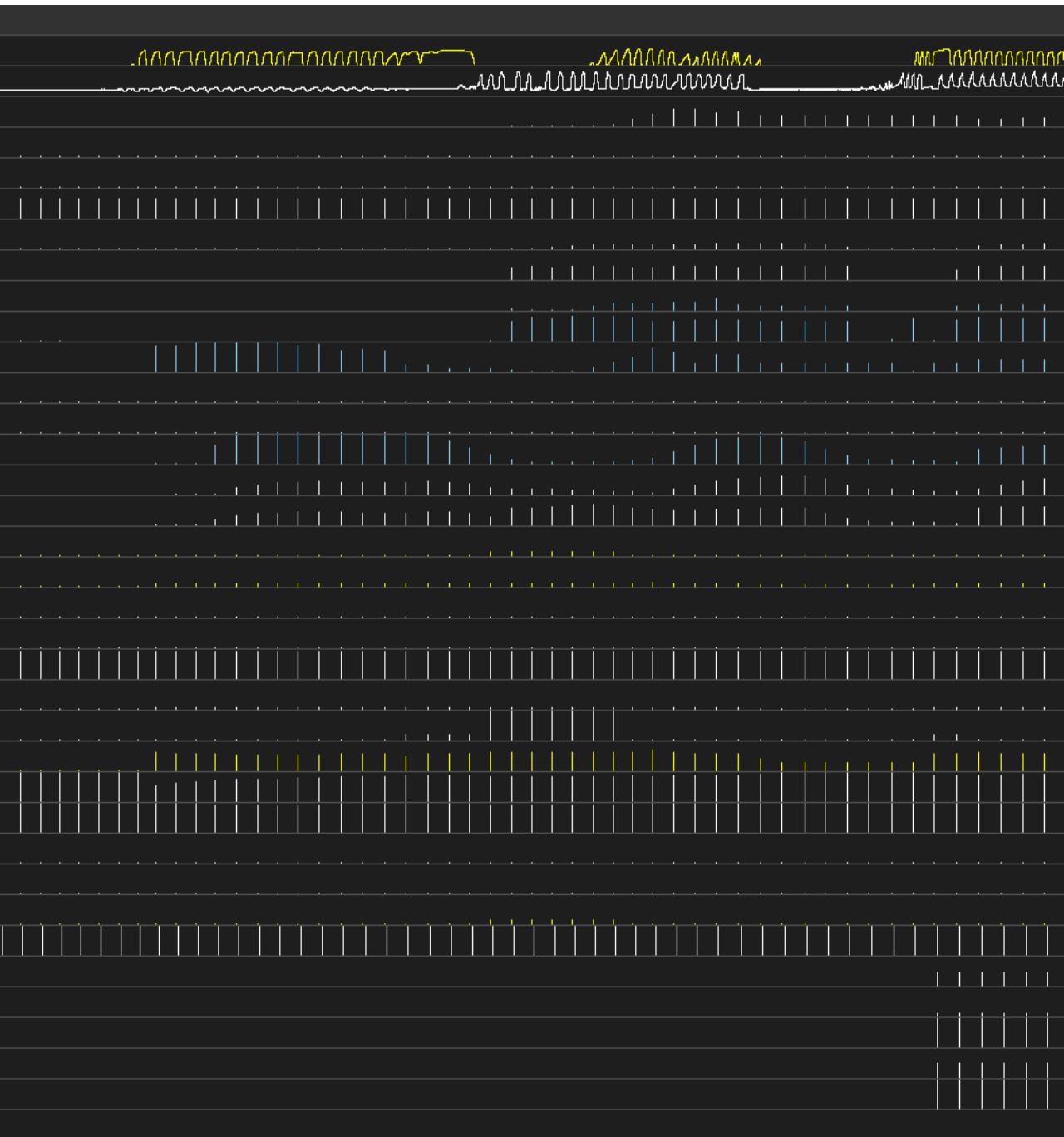


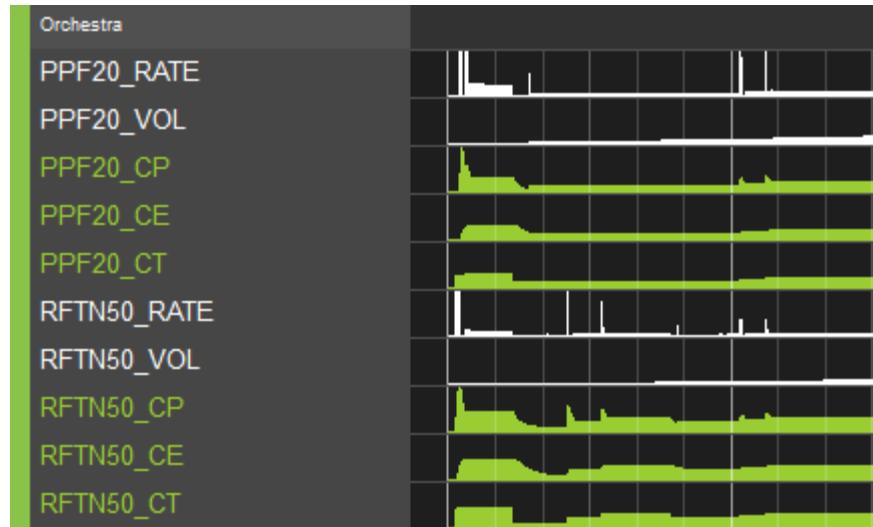
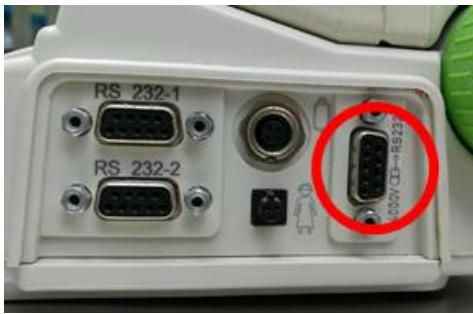
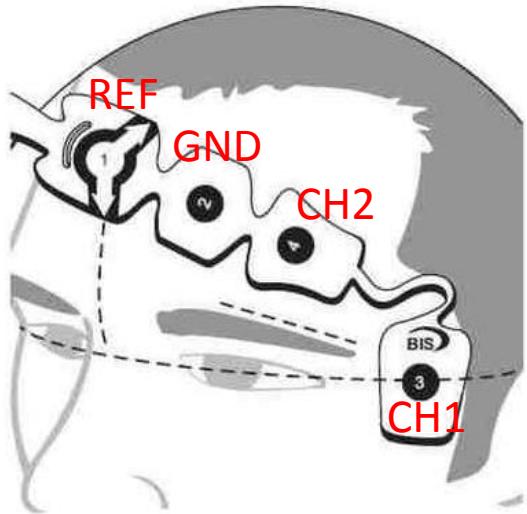
Primus  
CO2  
AWP  
COMPLIANCE  
INSP\_DES  
EXP\_DES  
PAMB\_MBAR  
MAWP\_MBAR  
PPLAT\_MBAR  
PEEP\_MBAR  
PIP\_MBAR  
TV  
MAC  
VENT\_LEAK  
MV  
RR\_CO2  
RR\_VF  
INCO2\_PERCENT  
ETCO2\_PERCENT  
FLOW\_N2O  
FLOW\_AIR  
FLOW\_O2  
ETCO2\_KPA  
INCO2  
ETCO2  
FE02  
FI02  
FIN20  
FEN20  
INCO2\_KPA  
SET\_FI02  
SET\_TV\_L  
SET\_INSP\_TM  
SET\_RR\_IPPV  
SET\_INTER\_PEEP  
SET\_PIP  
SET\_INSPIRATION\_PAUSE

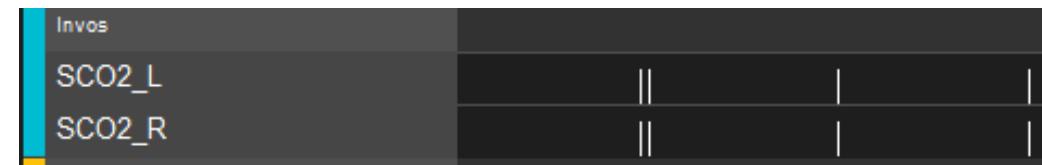
self respiration

mask bagging

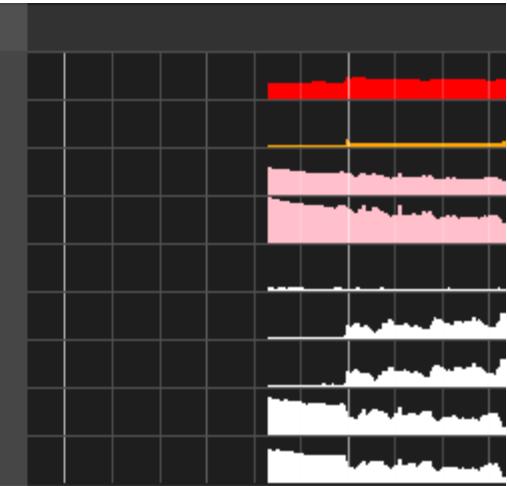
intubation







EV1000  
ART\_MBP  
CVP  
CO  
CI  
SVV  
SVR  
SVRI  
SV  
SVI



# Clinical Data

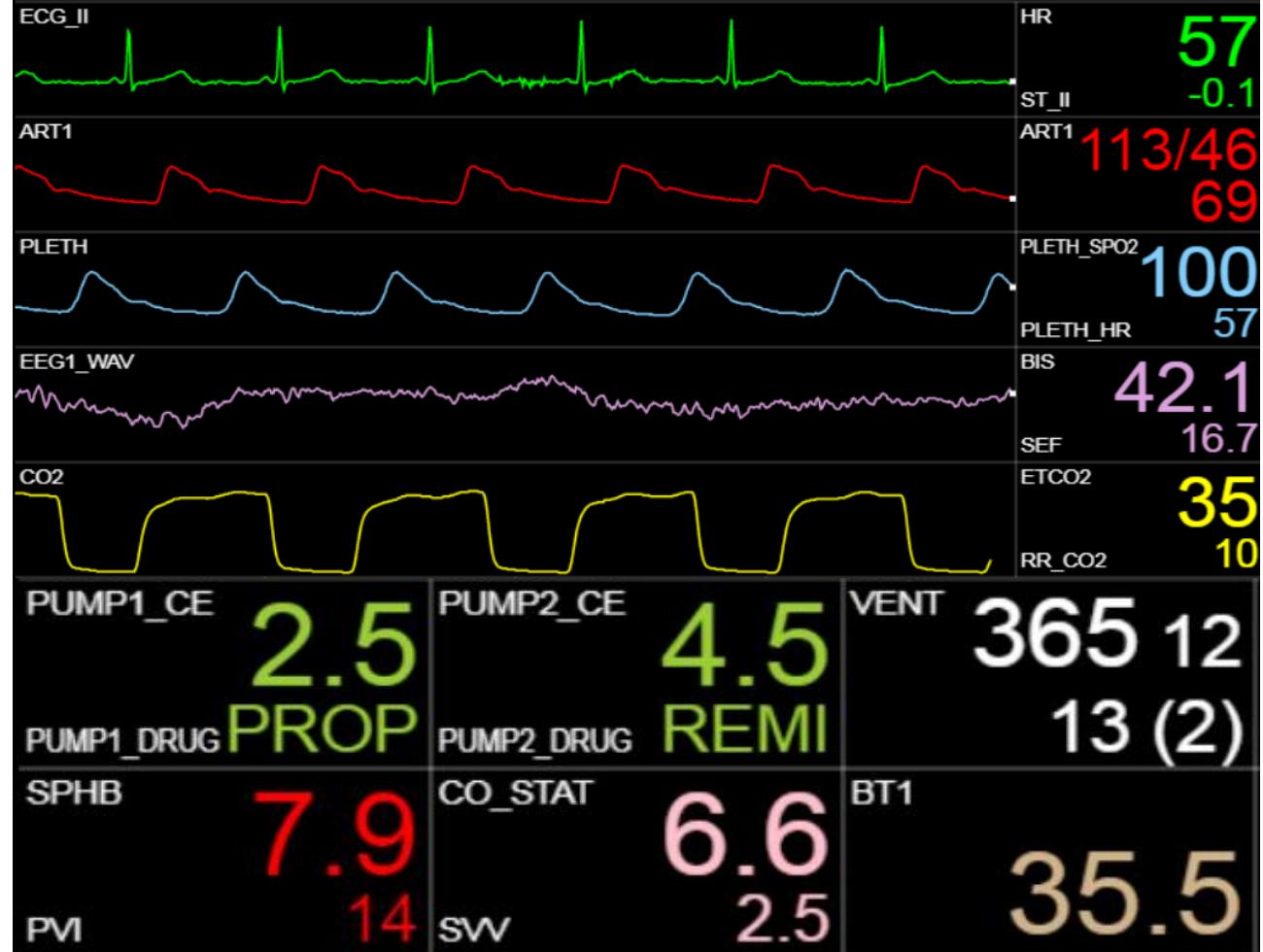
- **Demographic**
  - 나이, 성별, 키, 몸무게
- **Surgery & Anesthesia**
  - ASA classification; 응급 수술 여부
  - 수술 종류 (ICD10-코드)
  - 마취 종류
  - 마취제: Sevoflurane; Desflurane; Propofol TCI; Remifentanil TCI
  - 수술 시간, 마취 시간
- **Intraoperative data**
  - 연속 주입 약제: phenylephrine, norepinephrine, dopamine, epinephrine 등
- **Outcomes**
  - Postoperative stay; Postoperative ICU stay; Mortality

# 검사 결과

- 수술을 위한 입원 기간 중
- 혈액 검사 결과
  - Troponin I/T → Myocardial injury
  - Creatinine → AKI
  - ABGA → Pulmonary complication

CaseID	검사시행일시	검사명	검사결과
00001	2099-12-31 12:24	Triglyceride (TG)(검사24시간가능)	603
00001	2099-12-31 12:24	Sodium (serum)(검사24시간가능)	140
00001	2099-12-31 12:24	Calcium(검사24시간가능)	9.6
00001	2099-12-31 12:24	Phosphorus(검사24시간가능)	3.6
00001	2099-12-31 12:24	Glucose(검사24시간가능)	125
00001	2099-12-31 12:24	BUN(검사24시간가능)	16
00001	2099-12-31 12:24	Uric Acid(검사24시간가능)	6.2
00001	2099-12-31 12:24	Cholesterol(검사24시간가능)	217
00001	2100-01-01 04:12	Protein, total(검사24시간가능)	7.1
00001	2100-01-01 04:12	Albumin(검사24시간가능)	4.1
00001	2100-01-01 04:12	Bilirubin, total(검사24시간가능)	0.6
00001	2100-01-01 04:12	Alkaline phosphatase(검사24시간가능)	97
00001	2100-01-01 04:12	GOT (AST)(검사24시간가능)	32
00001	2100-01-01 04:12	GPT (ALT)(검사24시간가능)	23
00001	2100-01-01 04:12	eGFR(CKD EPI Cr)	68.6
00001	2100-01-01 04:12	Creatinine(검사24시간가능)	1.05
00001	2100-01-01 04:12	Potassium (serum)(검사24시간가능)	5.0
00001	2100-01-01 04:12	Chloride (serum)(검사24시간가능)	103
00001	2100-01-01 04:12	eGFR(MDRD)	68.7
00001	2100-01-01 04:12	HDL-Cholesterol(검사24시간가능)	31
00001	2100-01-01 04:12	LDL-Cholesterol(검사24시간가능)	61
00001	2100-01-01 04:12	Cystatin C	1.178
00001	2100-01-01 04:12	LDL-Cholesterol(검사24시간가능)	76
00001	2100-01-01 04:12	GOT (AST)(검사24시간가능)	32
00001	2100-01-02 08:31	eGFR(CKD EPI Cr)	64
00001	2100-01-02 08:31	Calcium(검사24시간가능)	10.0
00001	2100-01-02 08:31	Bilirubin, total(검사24시간가능)	0.8
00001	2100-01-02 08:31	Alkaline phosphatase(검사24시간가능)	63

# VitalDB를 활용한 연구



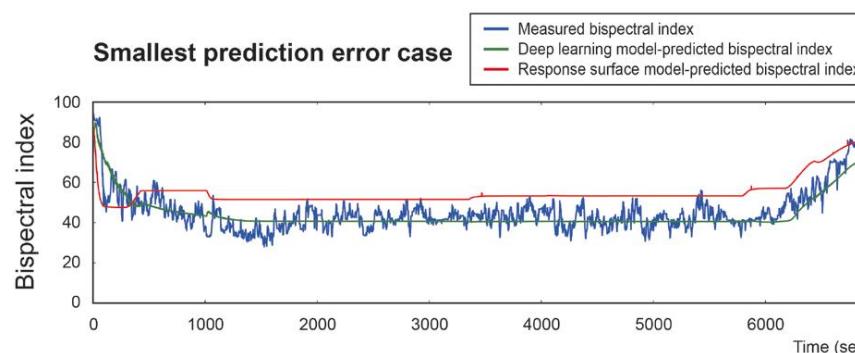
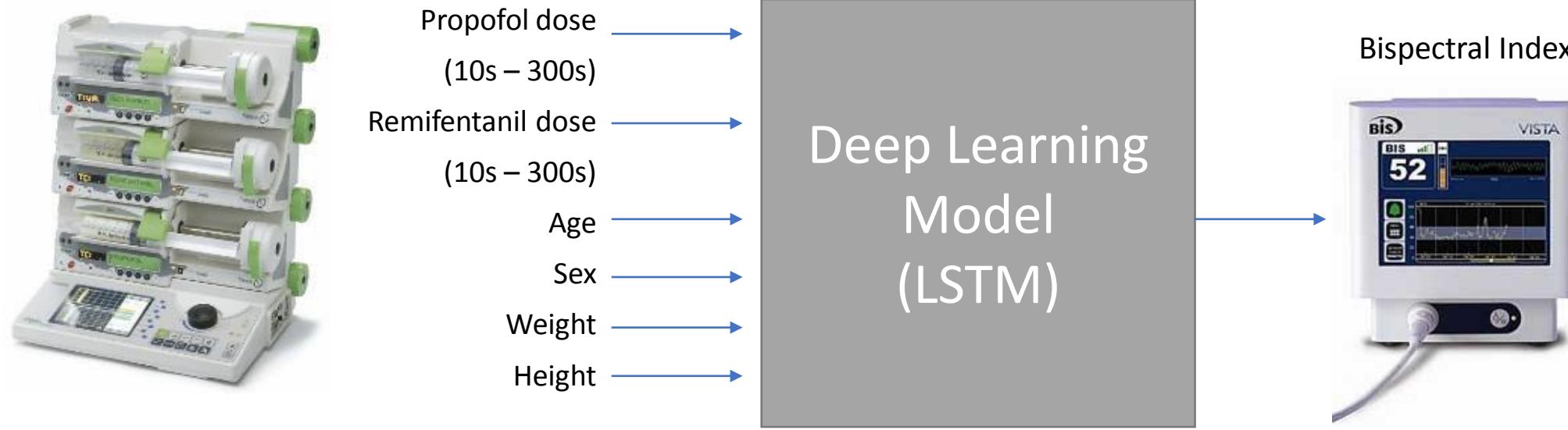
- 수술 중 파라미터와 술 후 사망, 심장합병증, 폐합병증 등 예후와의 관계
- 특정 수술 예후 예측
- 약물의 효과 예측
- 심전도, 혈압 파형으로부터 유용한 지표 개발
- 스마트 알람
- MIMIC-III, CDM 데이터와의 cross validation study

# Prediction of Bispectral Index during Target-controlled Infusion of Propofol and Remifentanil

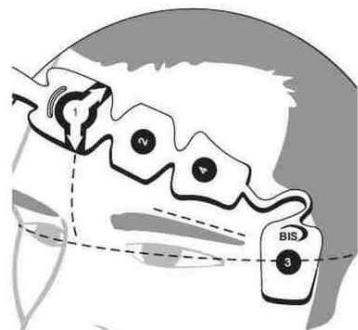
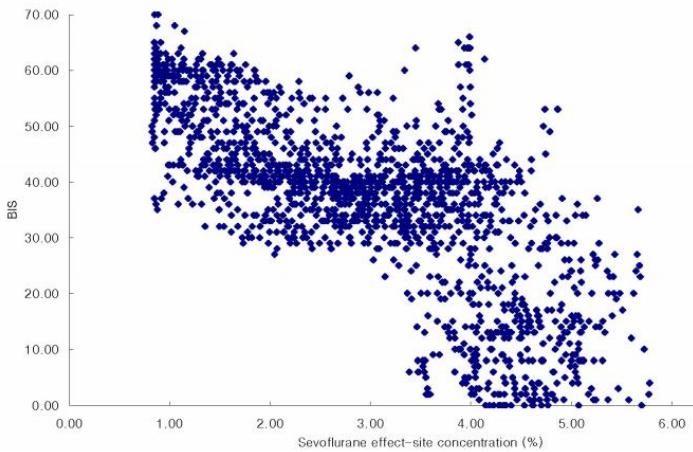
A Deep Learning Approach

ANESTHESIOLOGY 2018; 128:492-501

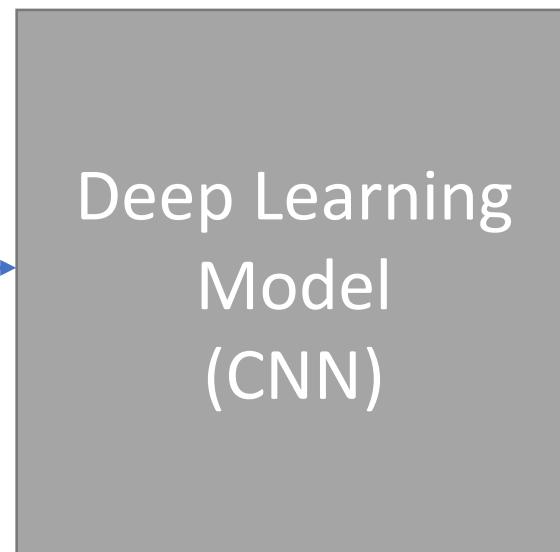
Hyung-Chul Lee, M.D., Ho-Geol Ryu, M.D., Ph.D., Eun-Jin Chung, M.D., Chul-Woo Jung, M.D., Ph.D.



AI model  
vs PK/PD model



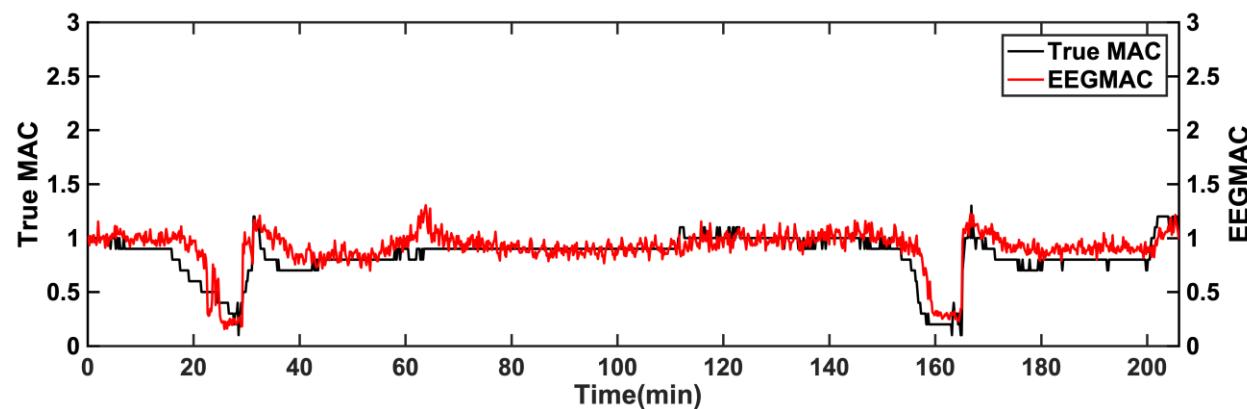
$10\text{s} \times 128\text{Hz} = 1280$  EEG samples



Sevoflurane MAC



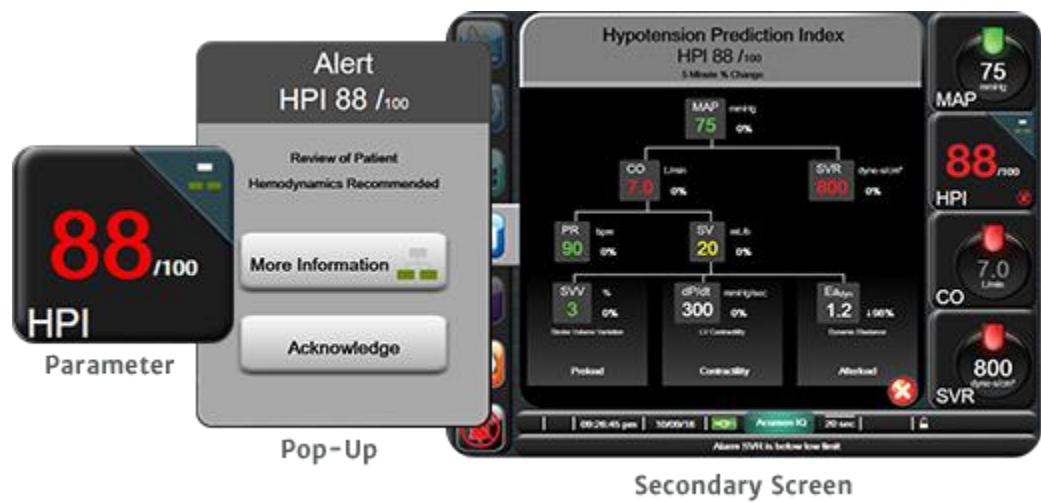
Mean  
Absolute  
Error  
0.16 MAC



AI model  
vs BIS

Under review

# 스마트 알람



Edward Lifesciences  
Hypotension Prediction Index (HPI, 2018 FDA cleared)

**Input:** Arterial waveform  
**Output:** Hypotension (MBP<65 mmHg) at least 1 min **10 to 15 min ahead**



Masimo Halo index (2010)  
**Input:** HR, SBP, BT, RR, SpO<sub>2</sub>, Hb  
**Output:** Patient deterioration

CCM 2018

## Development and Evaluation of an Automated Machine Learning Algorithm for In-Hospital Mortality Risk Adjustment Among Critical Care Patients\*

Ryan J. Delahanty, PhD<sup>1</sup>; David Kaufman, MD, FCCM<sup>2</sup>; Spencer S. Jones, PhD<sup>1</sup>

<b>Input Vars</b>	17 features (lab, vital signs)
<b>Output Var</b>	In-hospital Mortality
<b>Method</b>	Gradient Boosting Machine
<b>Training Data</b>	146,982 (36 hospitals) 90,191 (17 hospitals)
<b>Test Data</b>	17 hospitals
<b>Performance</b>	AUC=0.94 (17 features) AUC=0.91 (14 features)

cf. APACHE score (0.8)

Feature	Mean (SD)	Missingness	Relative influence
Last Glasgow Coma Score (integer 1-15)	13.4 (3)	8.98%	30.54%
Last shock index	0.7 (0.3)	0.26%	12.51%
Last measured shock index (HR/SBP) x age	43.7 (21.1)	0.26%	8.59%
Last blood urea nitrogen	25.1 (20.4)	3.54%	5.62%
Last mechanical ventilation status (Y/N)	14.4% (Y)	3.96%	5.18%
Last systolic blood pressure	123.5 (23.9)	0.15%	5.08%
Mean respiratory rate	19.2 (3.8)	0.10%	4.88%
Last pulse oximetry	96.1 (7.4)	0.44%	4.80%
Last evidence of any oxygen therapy (Y/N)	59.2% (Y)	3.96%	4.74%
Last CO2 measurement	24.5 (4.7)	3.26%	4.54%
Mean pulse oximetry	97 (2.6)	0.44%	4.09%
Last heart rate	82.4 (20.1)	0.08%	3.84%
Mean temperature Fahrenheit	98.3 (0.8)	3.75%	3.22%
Change in creatinine level	-0.14 (0.83)	3.59%	2.37%



Gradient  
Boosting  
Machine

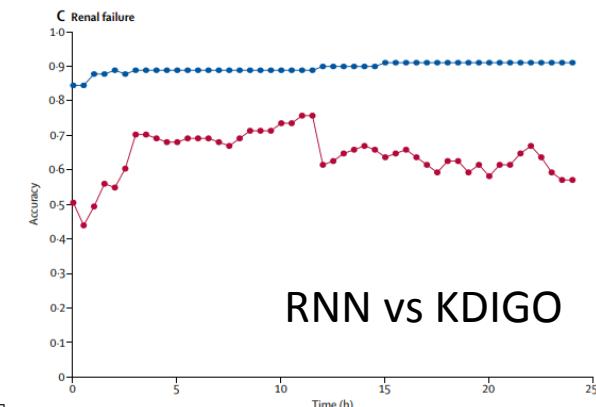
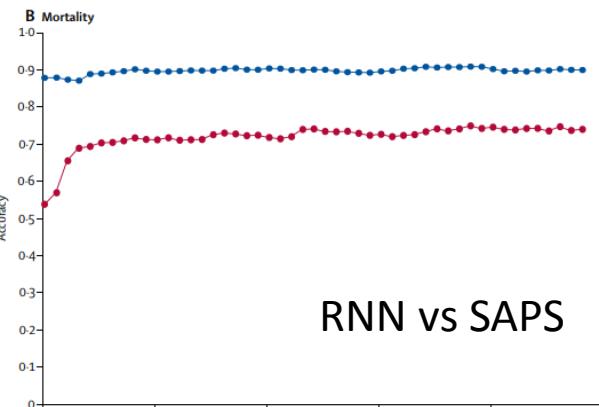
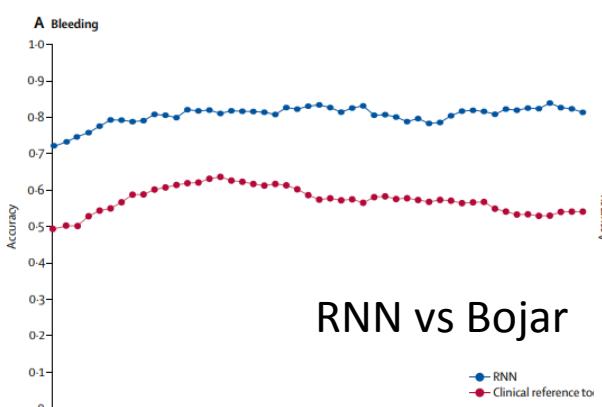
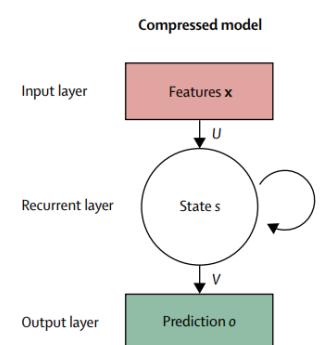
→ In hospital mortality

## Machine learning for real-time prediction of complications in critical care: a retrospective study

Alexander Meyer, Dina Zverinski, Boris Pfahringer, Jörg Kempfert, Titus Kuehne, Simon H Sündermann, Christof Stamm, Thomas Hofmann, Volkmar Falk, Carsten Eickhoff

Patient information	Age, sex, height, weight (four features)
Information relating to initial surgery	Anaesthesia type, American Society of Anesthesiologists Score, cardioplegic solution, aortic cross-clamp time, cardiopulmonary bypass time, anaesthetic monitoring time, surgery duration, surgery type, urgency (nine features)
Vital signs	Systolic, mean, and diastolic arterial pressure; systolic, mean, and diastolic pulmonary artery pressure; central venous pressure; ventilator $\text{FiO}_2$ setting; heart and respiratory frequency; body temperature (11 features)
Arterial blood gas	Bicarbonate, glucose, haemoglobin, oxygen saturation, partial pressure of carbon dioxide and oxygen, pH level, potassium, sodium (nine features)
Laboratory results	Albumin, bilirubin, urea, C-reactive protein, creatine kinase, $\gamma$ -glutamyltransferase, glutamic oxaloacetic transaminase, haemoglobin, haematocrit, international normalised ratio, creatinine, white blood cell count, lactate dehydrogenase, magnesium, partial thromboplastin time, platelets, prothrombin time (17 features)
Balance output	Bleeding rate, urine flow rate (two features)

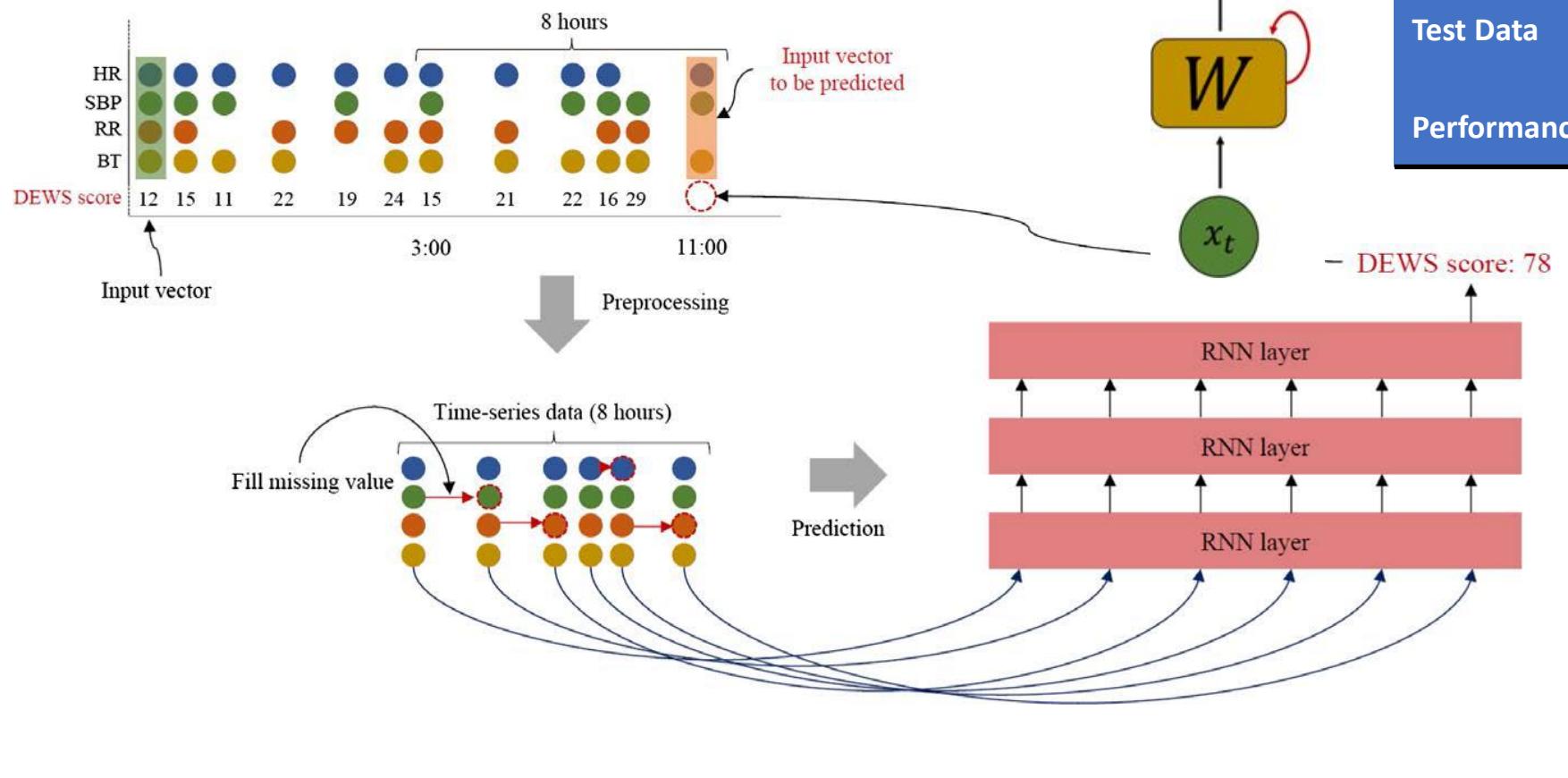
Input Vars	52 features
Output Var	Bleeding, mortality, renal failure within 24-hours after surgery
Reference	Bleeding – Bojar Mortality – SAPS Renal Failure – KDIGO
Method	RNN
Training Data	11,492 (Single center)
Test Data	53,423 (MIMIC-III)
Performance	Bleeding AUC=0.87 (cf. 0.58) Mortality AUC=0.95 (cf. 0.71) Renal Failure AUC=0.96 (cf. 0.72)



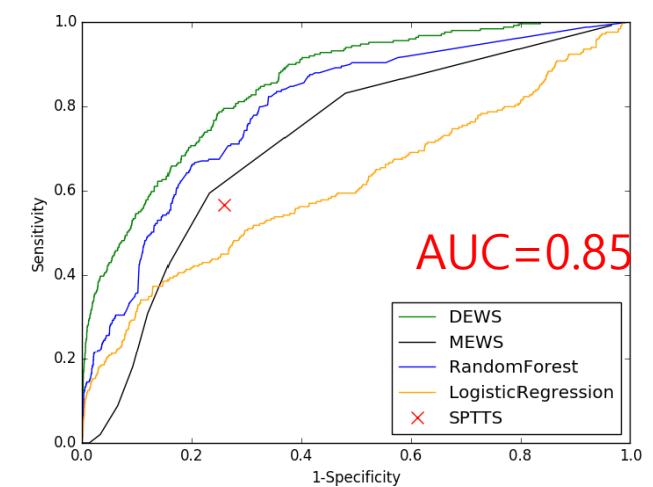
# An Algorithm Based on Deep Learning for Predicting In-Hospital Cardiac Arrest

Joon-myung Kwon, MD;\* Youngnam Lee, MS;\* Yeha Lee, PhD; Seungwoo Lee, BS; Jinsik Park, MD, PhD

JAHHA 2018



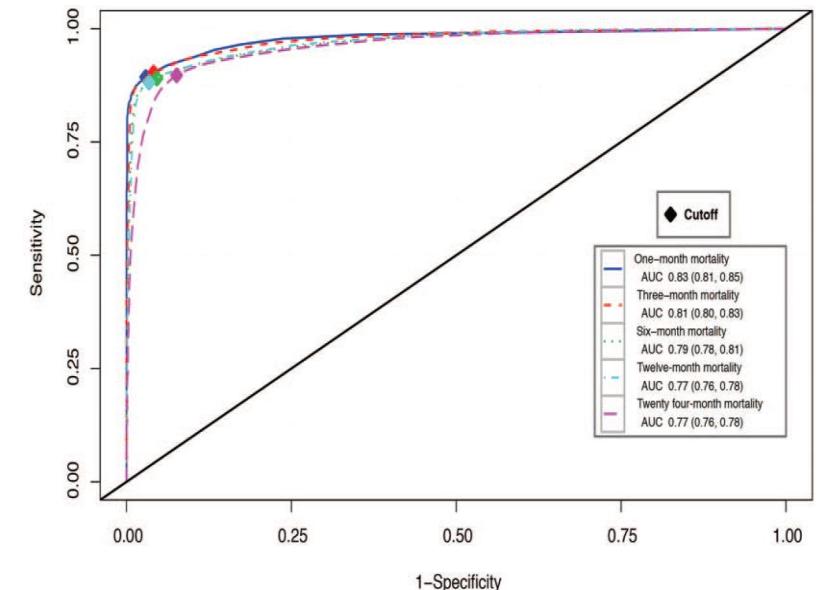
<b>Input Vars</b>	4 features (8 hours)
<b>Output Var</b>	Cardiac arrest (24 hrs ahead)
<b>Reference</b>	Modified early warning score
<b>Method</b>	RNN
<b>Training Data</b>	46,725 (single center)
<b>Test Data</b>	3,634 (separated period) 1,772 (another center)
<b>Performance</b>	AUC=0.85 (cf. 0.603)



# *MySurgeryRisk*: Development and Validation of a Machine-learning Risk Algorithm for Major Complications and Death After Surgery

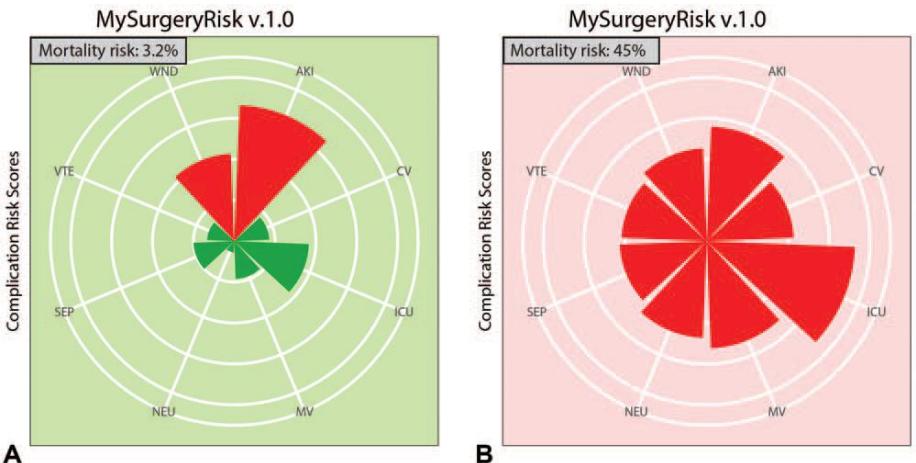
2018 Annals of surgery (impact factor : 9.2)

- Single-center cohort of 51,457 surgical patients
- 69 preoperative variables
- AKI, sepsis, VTE, ICU > 48hr, MV > 48 hrs, wound, neurologic, cardiovascular complications, and death up to 24 months after surgery
- Generalized additive model (GAM)



	Prevalence	Sensitivity	Specificity	PPV	NPV	Accuracy
1-month mortality	3.4%	0.39 (0.30, 0.47)	0.93 (0.91, 0.95)	0.18 (0.14, 0.21)	0.98 (0.97, 0.98)	0.92 (0.90, 0.93)
3-month mortality	6.7%	0.46 (0.41, 0.52)	0.91 (0.90, 0.93)	0.27 (0.25, 0.30)	0.96 (0.96, 0.96)	0.88 (0.87, 0.90)
6-month mortality	9.4%	0.44 (0.41, 0.49)	0.91 (0.89, 0.92)	0.32 (0.29, 0.36)	0.94 (0.94, 0.95)	0.86 (0.85, 0.87)
12-month mortality	12.8%	0.38 (0.35, 0.43)	0.91 (0.89, 0.92)	0.37 (0.34, 0.40)	0.91 (0.90, 0.92)	0.84 (0.83, 0.85)
24-month mortality	17.0%	0.41 (0.38, 0.46)	0.90 (0.88, 0.91)	0.36 (0.33, 0.38)	0.91 (0.91, 0.92)	0.84 (0.82, 0.84)

c



# GE MURAL



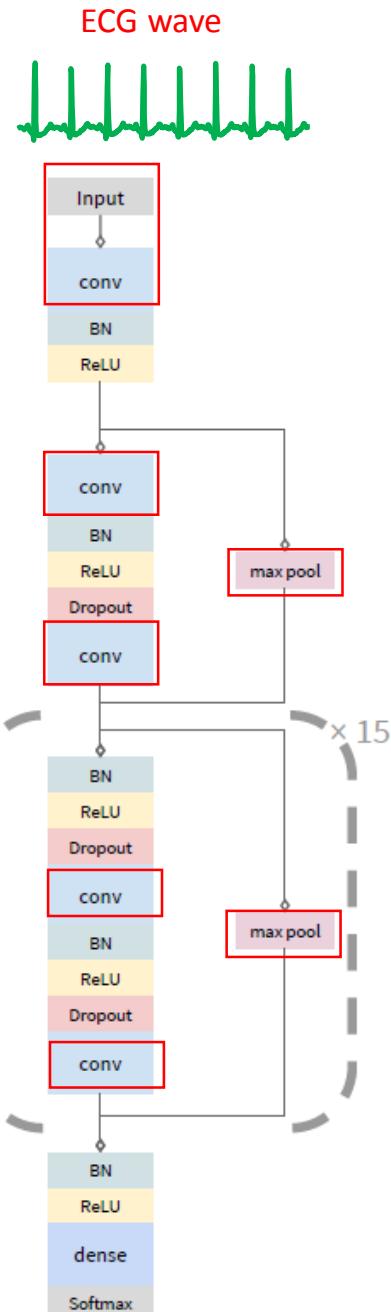
- 다양한 모니터 지원
- Lab 등 EMR과도 통합
- 현재 FDA 승인 진행 중
- Sepsis, AKI, Ventilator associated pneumonia 등의 인공지능 예측 알고리즘을 탑재

## 2018.12, impact factor 33

### Cardiologist-level arrhythmia detection and classification in ambulatory electrocardiograms using a deep neural network

Awni Y. Hannun<sup>1,6\*</sup>, Pranav Rajpurkar<sup>1,6</sup>, Masoumeh Haghpanahi<sup>2,6</sup>, Geoffrey H. Tison<sup>3,6</sup>, Codie Bourn<sup>2</sup>, Mintu P. Turakhia<sup>4,5</sup> and Andrew Y. Ng<sup>1</sup>

	Algorithm AUC (95%)
	Sequence <sup>a</sup>
Atrial fibrillation and flutter	0.973 (0.966-0.980)
AVB	0.988 (0.983-0.993)
Bigeminy	0.997 (0.991-1.000)
EAR	0.913 (0.889-0.937)
IVR	0.995 (0.989-1.000)
Junctional rhythm	0.987 (0.980-0.993)
Noise	0.981 (0.973-0.989)
Sinus rhythm	0.975 (0.971-0.979)
SVT	0.973 (0.960-0.985)
Trigeminy	0.998 (0.995-1.000)
Ventricular tachycardia	0.995 (0.980-1.000)
Wenckebach	0.978 (0.967-0.989)
Frequency-weighted average	0.978



Afib, AVB, Bigeminy, Junctional, ...

<b>Input Vars</b>	Single lead ECG waveform
<b>Output Var</b>	12 arrhythmia classification
<b>Reference</b>	Cardiologists
<b>Method</b>	CNN
<b>Training Data</b>	91,232 (Single center)
<b>Test Data</b>	328
<b>Performance</b>	AUC=0.97 F-score = 0.84 (cf. Cardiologists 0.78)



Andrew Ng



# For Clinicians



# For Engineers

The screenshot shows the VitalDB Data Bank interface. At the top, it has a navigation bar with links to Docs, Data Bank, Vital Recorder, Web Monitoring, Forum, and vitaldb2017. The main section is titled 'Data Bank' and describes it as an 'Open Access Repository of Vital Signs.' It includes a note about the study approval and a download count of 292 times, 13167 cases, and 48009 tracks. Below this, there are sections for 'Database' and 'Devices & Parameters'. In the 'Database' section, the ID is set to SNUHOR01. In the 'Devices & Parameters' section, there are three columns of checkboxes for selecting variables from different devices: SNUADC (TramRac-4A), Solar 8000M, and Primus. The checkboxes are color-coded by device: grey for SNUADC, blue for Solar 8000M, and light blue for Primus. A note at the bottom states 'Download limitation: 1) Up to 20 variables including a maximum of 4 waveform variables 2) Unlimited case files' and indicates '3376 cases • 4 vars • 1 wave'.

# Thank you

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