

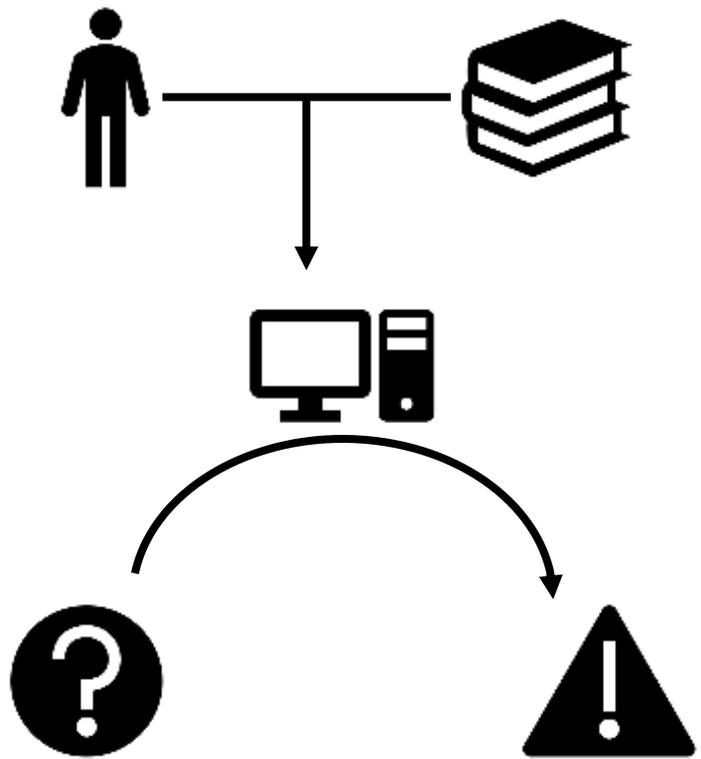
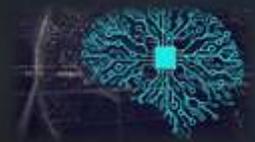
Using the Big data-based prediction model for RRS

Joon-myung Kwon

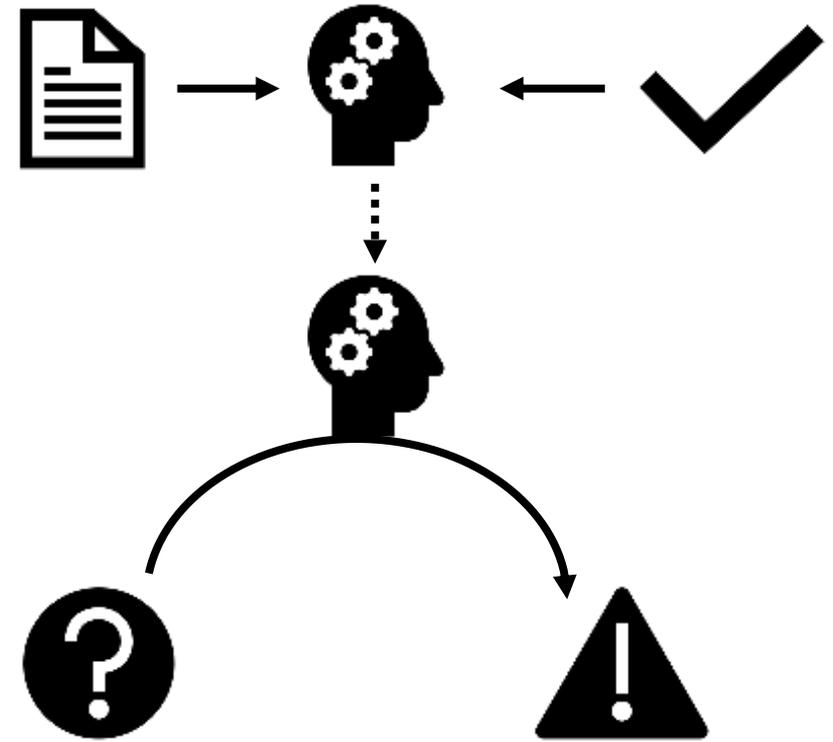
**Artificial intelligence and big Data Center, Sejong Medical Research Institute
Emergency and Critical care Medicine, Mediplex Sejong Hospital**



Introduction: Machine Learning



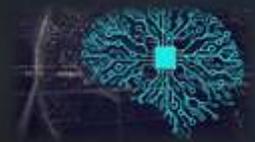
Expert System



Machine Learning



Deep Learning: Deep Neural Network



1. Model derivation raw data

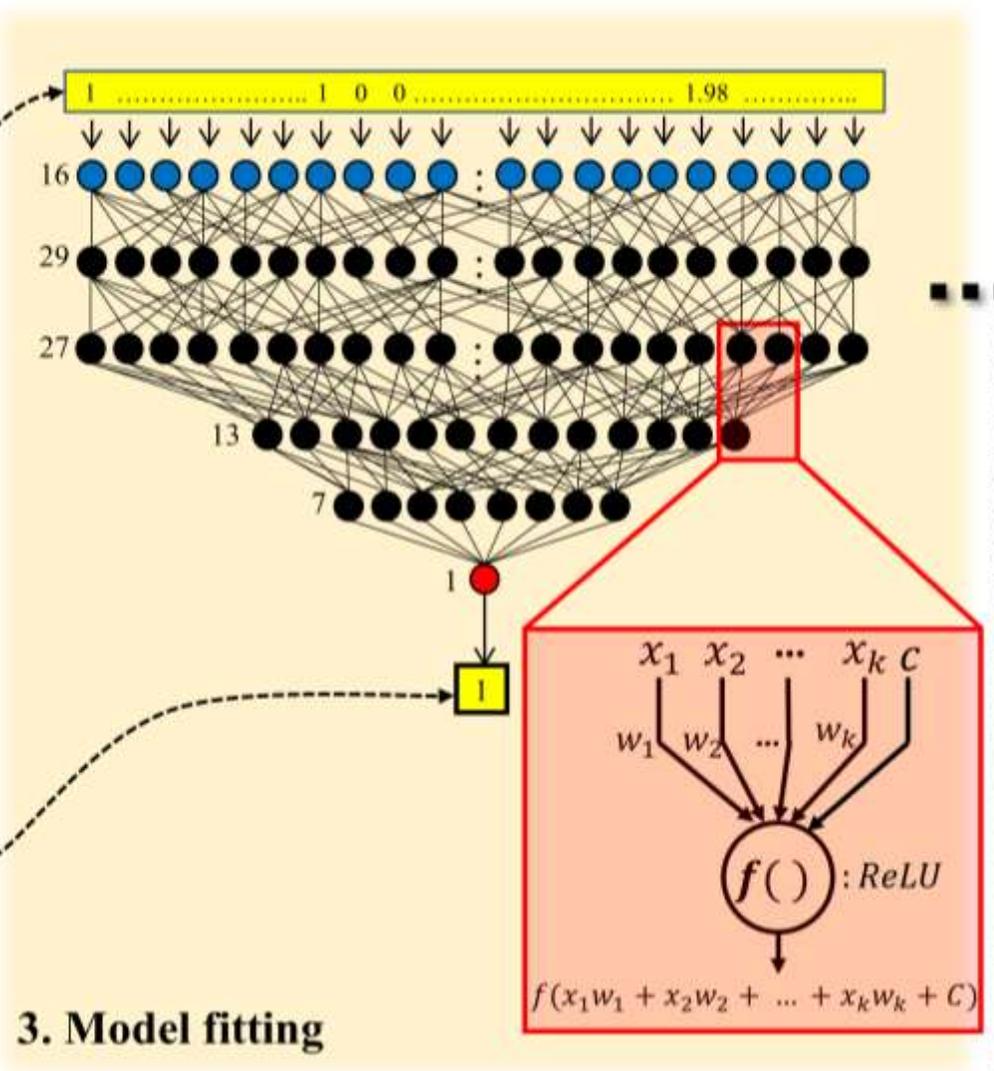
sex	.. Place ...	age	.. Neurologic recovery
M	Home	48	YES
F	Public	64	NO
M	Home	78	NO
M	Others	83	NO
F	Ambulance	72	NO
F	Home	68	NO
F	Home	92	NO
M	Public	72	NO
M	Home	58	YES
F	Public	77	NO
F	Others	58	NO
F	Home	67	NO
M	Home	73	NO
F	Ambulance	81	NO
...

Numeric change for Categorical variable Normalization for continuous variable

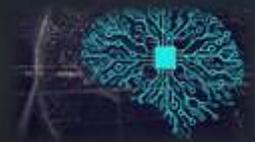
Sex	.. Home	Public	Ambulance	.. age
1	1	0	0	... -1.98
0	0	1	0	... -0.59
1	1	0	0	... 0.63
1	0	0	0	... 1.06
0	0	0	1	... 0.11

Outcome variable

Y
1
0
0
0
0
0
0



Kwon JM, Jeon KH, et al. Deep-learning-based out-of-hospital cardiac arrest prognostic system to predict clinical outcomes. Resuscitation. 2019.



— **AEGIS** project — cardiac **A**rrest **E**arly warning al**G**orithm **I**n **S**ejong hospital

Joon-myung Kwon¹, Youngnam Lee², Yeha Lee², Seungwoo Lee², Jinsik Park¹

Mediplex Sejong Hospital¹, VUNO²





Deep Learning: AEGIS with LSTM

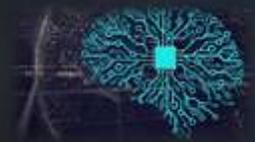


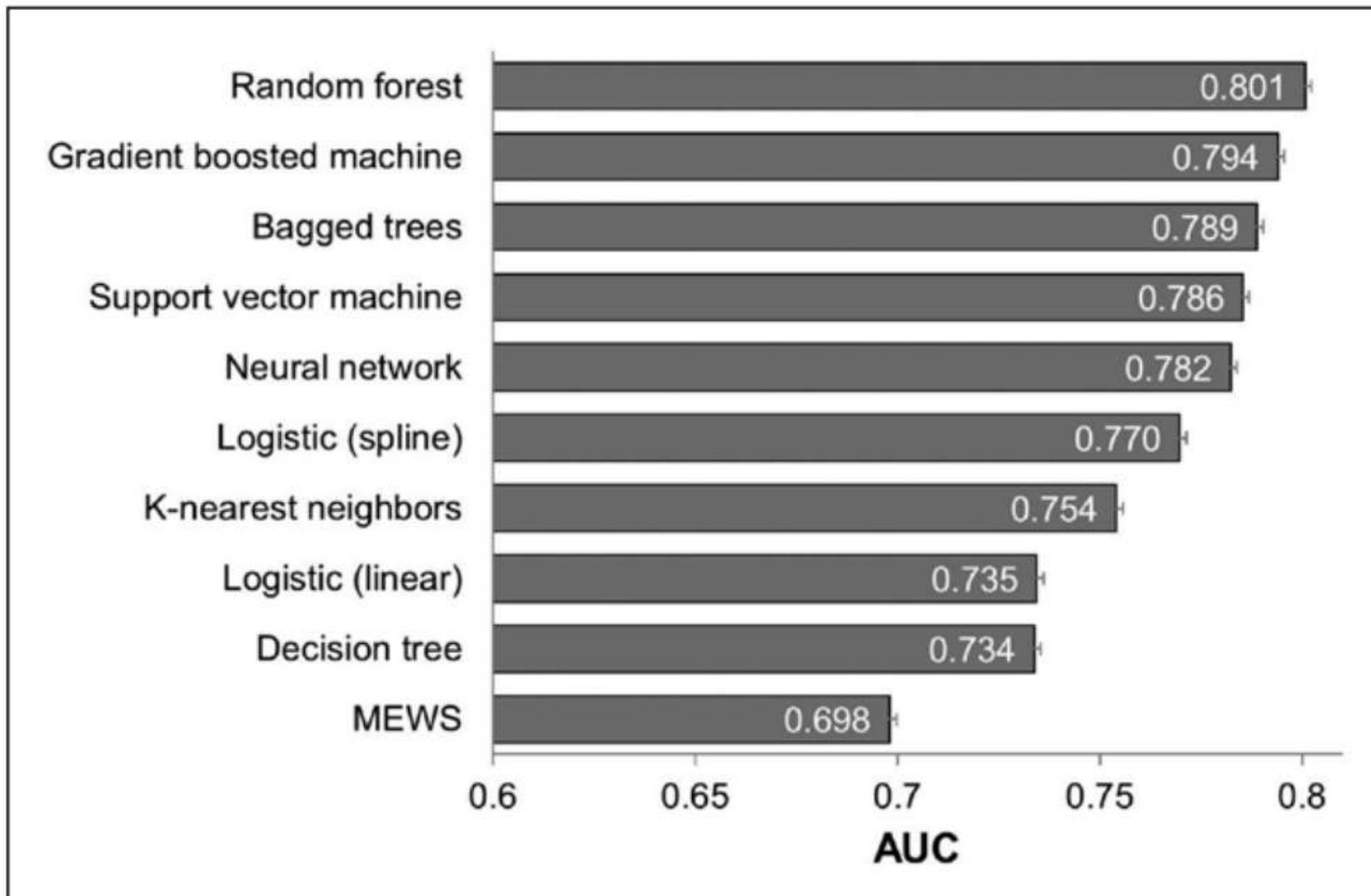
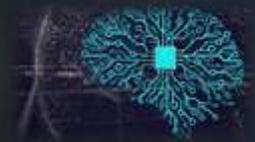
Table 4 The performance of 30 SPTTS, with 1 and >1 observational value exceeding preset limits, using hospital mortality as the outcome

Class	System evaluated	Sensitivity (%)		Specificity (%)		PPV		NPV		Triggers	
		1	>1	1	>1	1	>1	1	>1	1	>1
1	Bell (standard) ⁴	15.1	1.9	95.2	99.8	22.4	47.1	92.5	91.8	563	34
2	Bell (extended) ⁴	29.8	4.8	86.9	99.3	17.2	38.1	93.1	92.0	1451	105
3	Bell (restricted) ⁴	7.3	0.4	98.1	100.0	26.1	42.9	92.1	91.7	234	7
4	Ball ²⁸	28.3	5.4	88.0	98.9	17.7	31.7	93.1	92.0	1336	142
5	Parissopoulos ¹³	32.6	10.2	88.3	98.8	20.3	43.1	93.5	92.3	1339	197
6	Hickey ⁵⁶	24.7	6.0	91.9	99.4	21.8	48.1	93.0	92.1	947	104
7	Salamonson ⁸⁸	19.0	3.1	95.0	99.7	25.7	53.1	92.8	91.9	618	49
8	Buist ³²	23.0	4.8	93.4	99.5	24.1	47.1	93.0	92.0	797	85
9	Bellomo ³⁰	23.1	4.9	93.2	99.5	23.8	47.7	93.0	92.0	811	86
10	Jones ⁷¹	25.4	6.5	92.3	99.4	23.1	49.1	93.1	92.1	916	110
11	Green ⁵³	26.7	6.9	91.3	99.3	21.8	46.4	93.2	92.1	1023	125
12	Harrison (early) ⁵⁴	52.8	17.2	69.1	95.8	13.5	27.5	94.1	92.7	3271	524
13	Harrison (late) ⁵⁴	17.4	2.2	95.4	99.9	25.8	60.0	92.7	91.8	562	30
14	Smith ⁸⁹	50.5	15.7	73.5	95.5	14.8	24.3	94.2	92.5	2850	539
15	de Pennington ⁴⁴	24.1	4.8	91.7	99.4	20.9	41.7	93.0	92.0	964	96

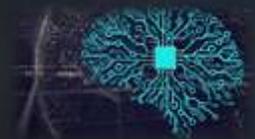
Smith GB, et al. A review, and performance evaluation, of single-parameter “track and trigger” systems. *Resuscitation* 2008;79(1):11–21.



Deep Learning: AEGIS with LSTM



Churpek MM, et al. Multicenter Comparison of Machine Learning Methods and Conventional Regression for Predicting Clinical Deterioration on the Wards. *Crit Care Med.* 2016;44(2):368–374.



Cardiac Arrest *Early* warning alGorithm In Sejong Hospital

Joon-myung Kwon¹, Youngnam Lee², Yeha Lee², Seungwoo Lee², Jinsik Park¹



¹
세종병원

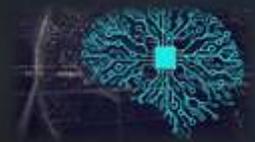


²

First Meeting: 2017. 1. 4



Deep Learning: AEGIS with LSTM

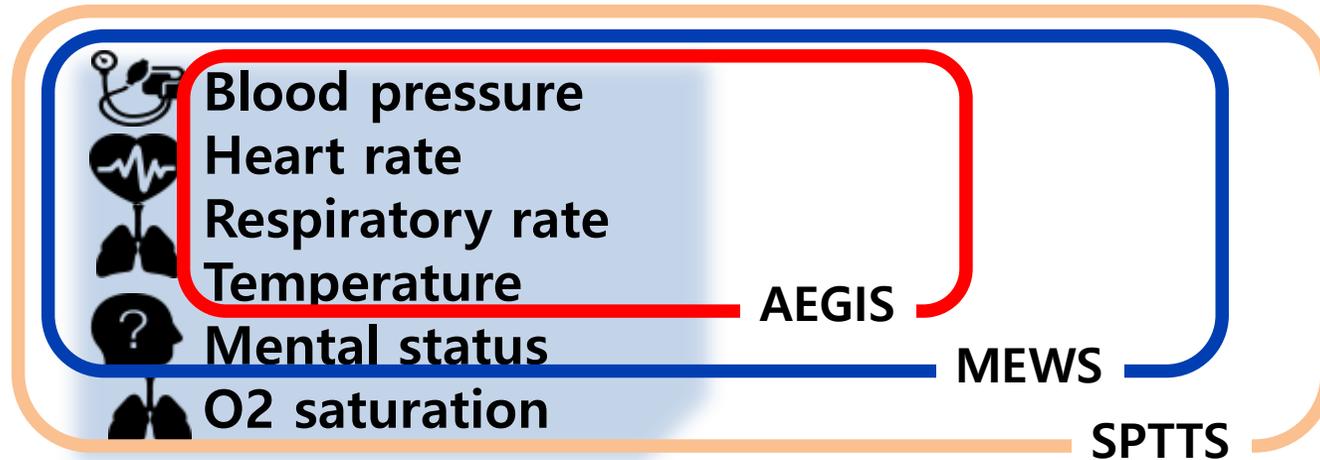


7 years Sejong hospital EHR data

1,217 IHCA patients

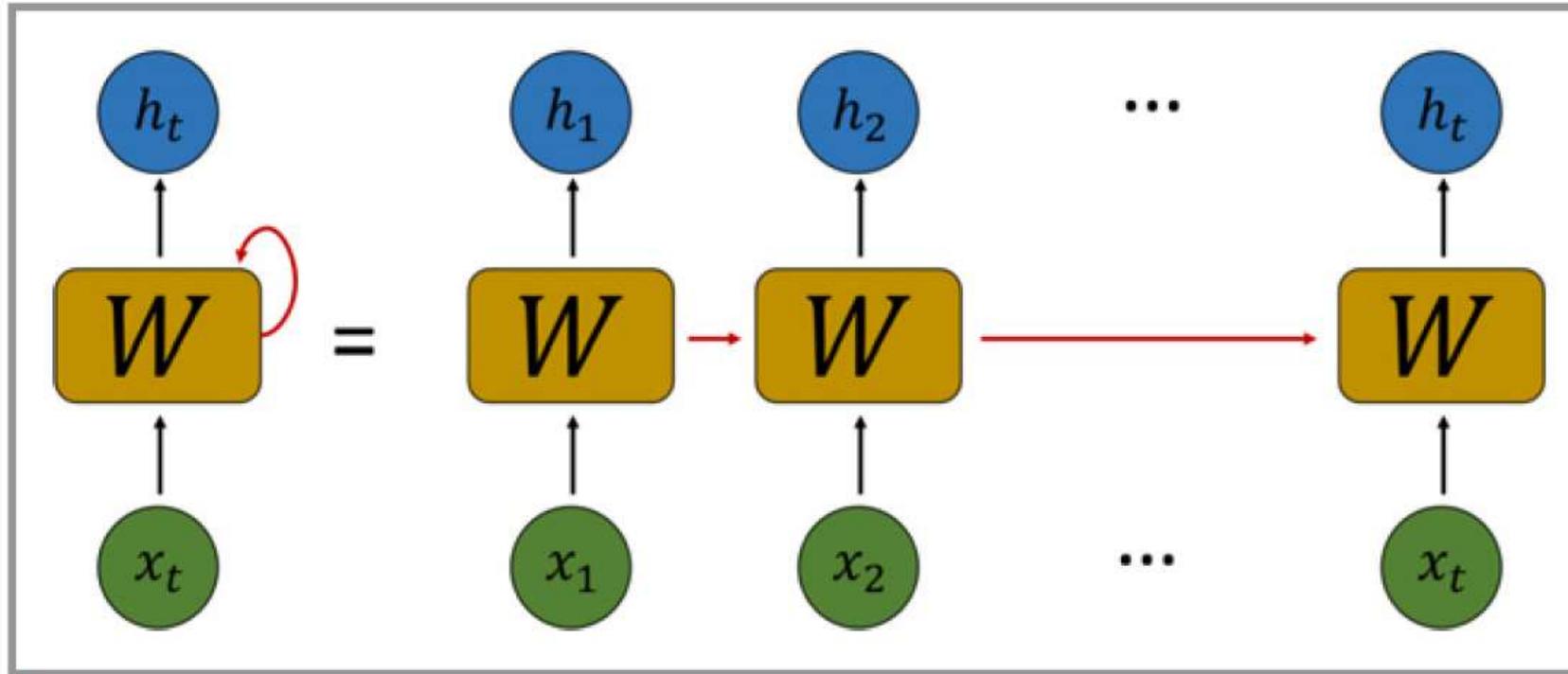
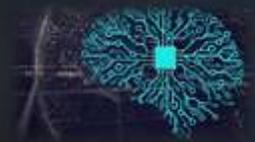
49,302 other patients

2,872,275 data set





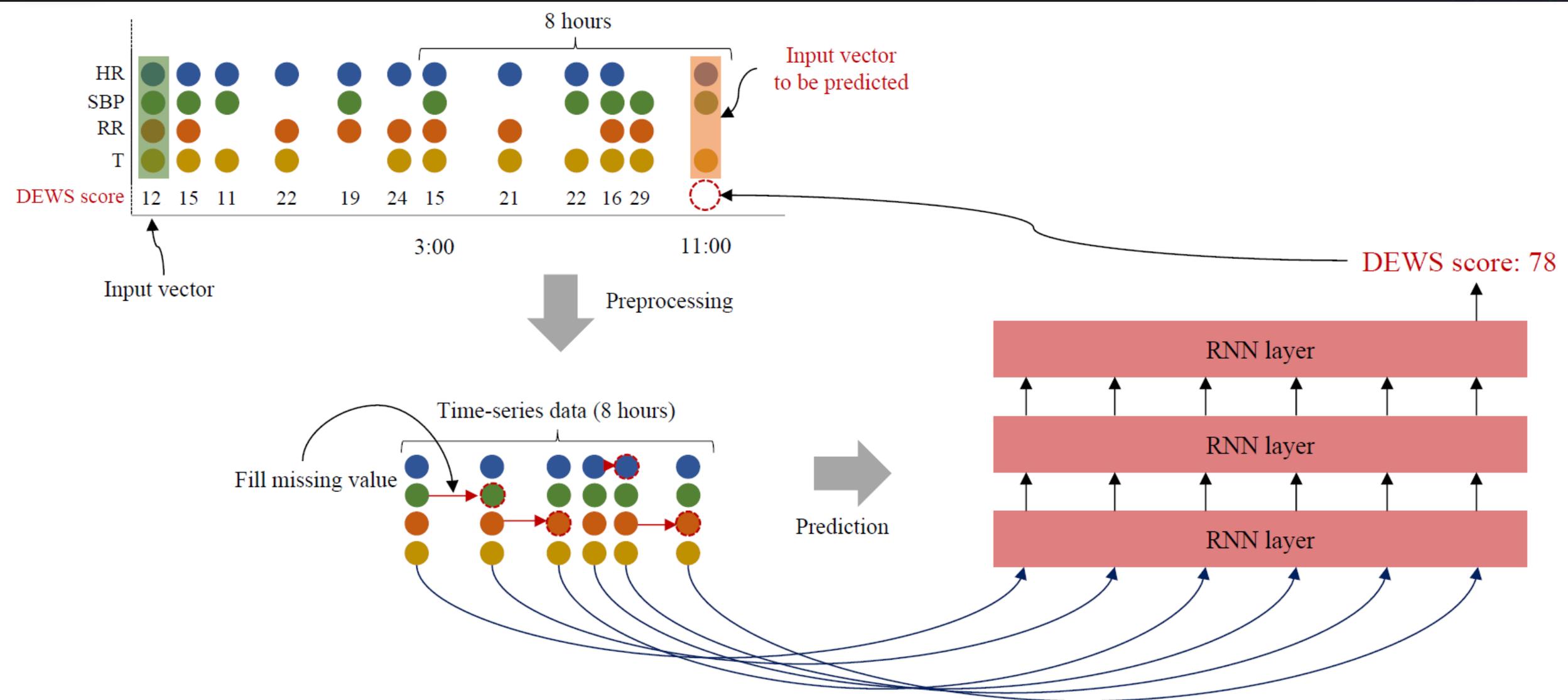
Deep Learning: AEGIS with LSTM



Kwon JM, Lee Y, Lee Y, et al. An Algorithm Based on Deep Learning for Predicting In-Hospital Cardiac Arrest. J Am Heart Assoc. 2018;7:e008678.



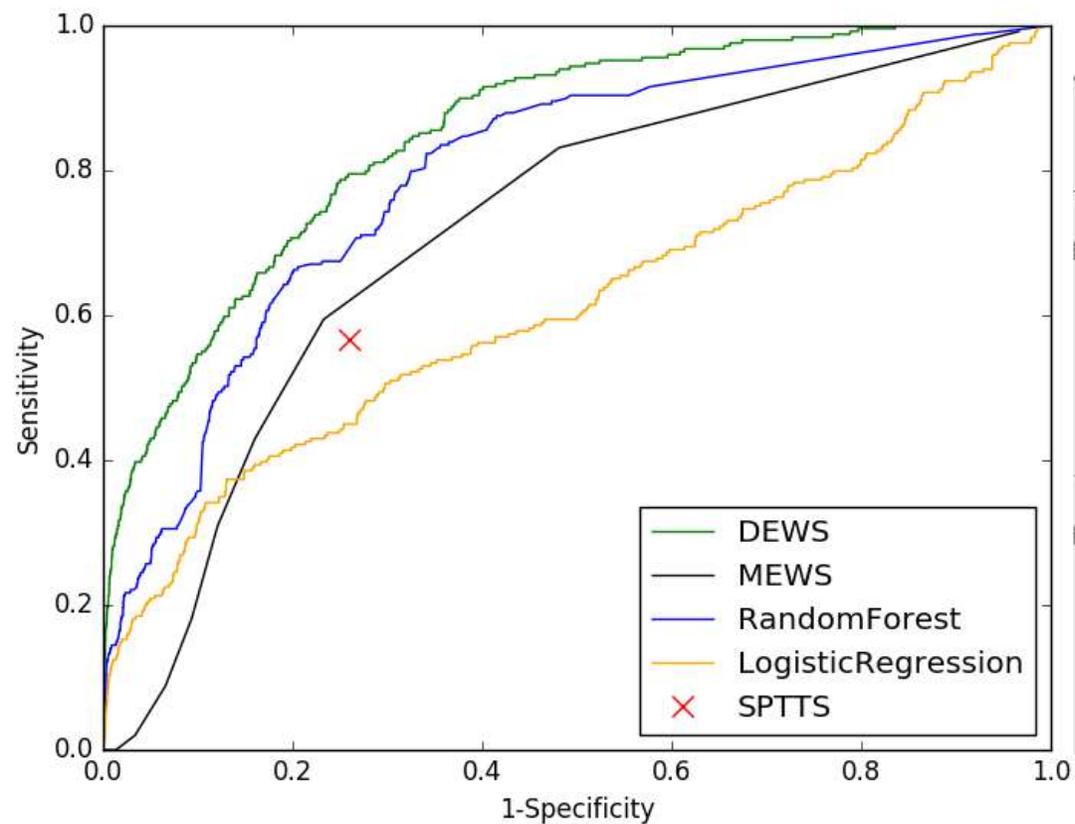
Deep Learning: AEGIS with LSTM



Kwon JM, Lee Y, Lee Y, et al. An Algorithm Based on Deep Learning for Predicting In-Hospital Cardiac Arrest. J Am Heart Assoc. 2018;7:e008678.



Deep Learning: AEGIS with LSTM

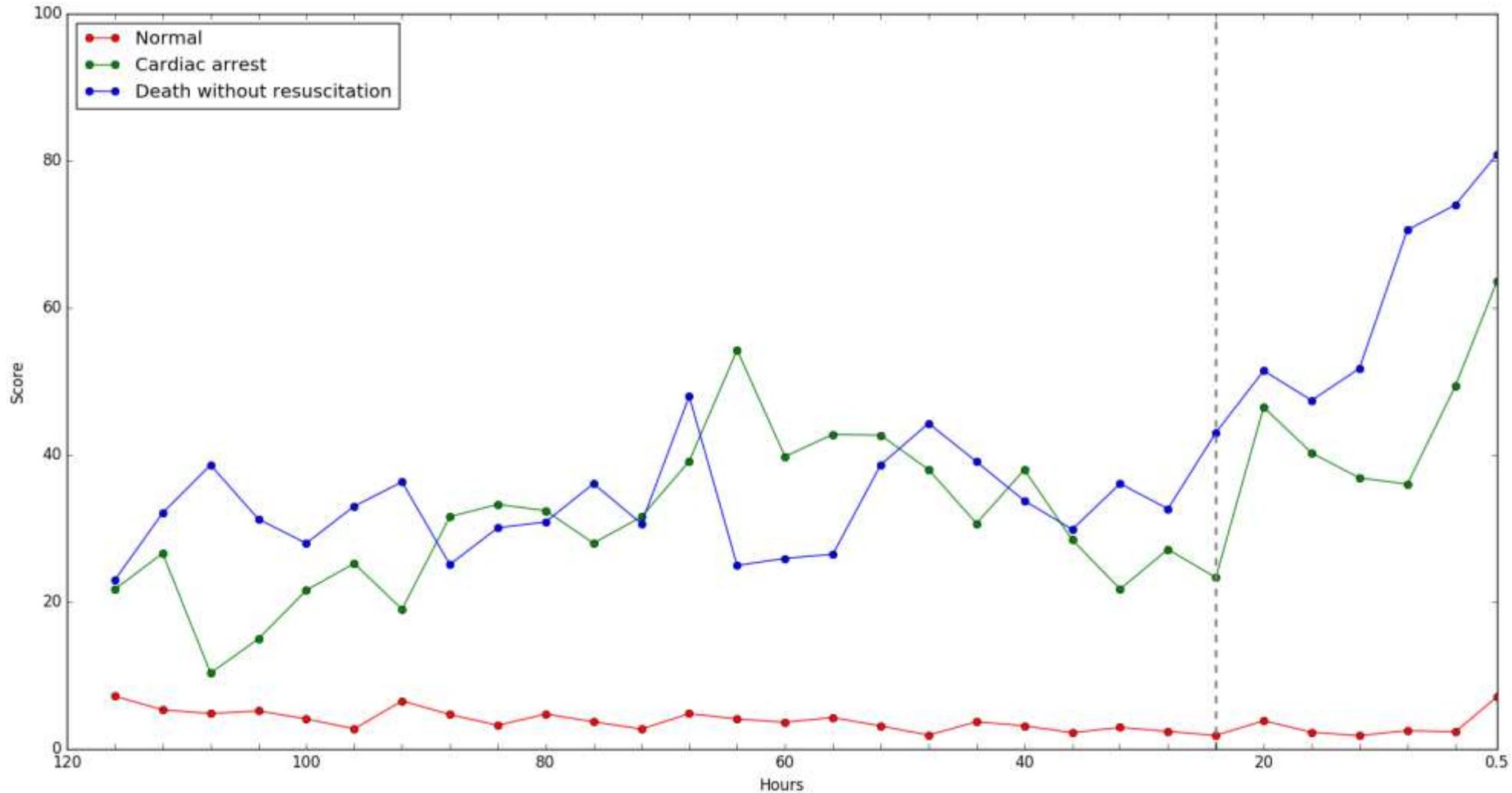


	Hospital A				Hospital B			
	AUROC	(95% CI)	AUPRC	(95% CI)	AUROC	(95% CI)	AUPRC	(95% CI)
Predicting cardiac arrest								
DEWS	0.850	(0.847-0.853)	0.044	(0.040-0.046)	0.837	(0.829-0.857)	0.239	(0.219-0.257)
MEWS	0.603	(0.603-0.603)	0.003	(0.003-0.003)	0.765	(0.765-0.765)	0.028	(0.028-0.028)
Random Forest	0.780	(0.776-0.787)	0.014	(0.012-0.014)	0.823	(0.812-0.828)	0.203	(0.184-0.218)
Logistic Regression	0.613	(0.607-0.620)	0.007	(0.006-0.007)	0.780	(0.767-0.795)	0.057	(0.051-0.061)
Predicting death without attempted resuscitation								
DEWS	0.926	(0.925-0.929)	0.188	(0.180-0.194)	0.911	(0.910-0.922)	0.221	(0.210-0.229)
MEWS	0.815	(0.815-0.815)	0.032	(0.032-0.032)	0.894	(0.894-0.894)	0.172	(0.172-0.172)
Random Forest	0.910	(0.908-0.913)	0.065	(0.061-0.068)	0.910	(0.908-0.911)	0.150	(0.141-0.160)
Logistic Regression	0.655	(0.650-0.661)	0.020	(0.019-0.020)	0.806	(0.802-0.812)	0.112	(0.105-0.118)

Kwon JM, Lee Y, Lee Y, et al. An Algorithm Based on Deep Learning for Predicting In-Hospital Cardiac Arrest. J Am Heart Assoc. 2018;7:e008678.



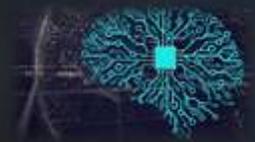
Deep Learning: AEGIS with LSTM



Kwon JM, Lee Y, Lee Y, et al. An Algorithm Based on Deep Learning for Predicting In-Hospital Cardiac Arrest. *J Am Heart Assoc.* 2018;7:e008678.



Deep Learning: AEGIS with LSTM



Implement: 2017. 5

메디플렉스 세종병원 신속대응팀

SCOUT *Sejong Critical Care
OUTreach Team*

수축기 혈압 : 85 mmHg이하

맥박수 : 50회/분 이하 or 130회/분 이상

호흡수 : 8회/분 이하 or 25회/분 이상

SpO2 : 89% 이하

갑작스러운 의식변화 or 경련

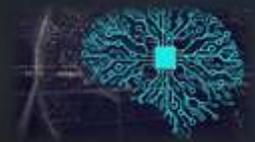
PaO2<55, PaCO2>50, Lactate>2, K>6.5

이외에도 언제든지 환자의 악화가 염려될 때

신속대응팀에게
연락하세요 **8617**

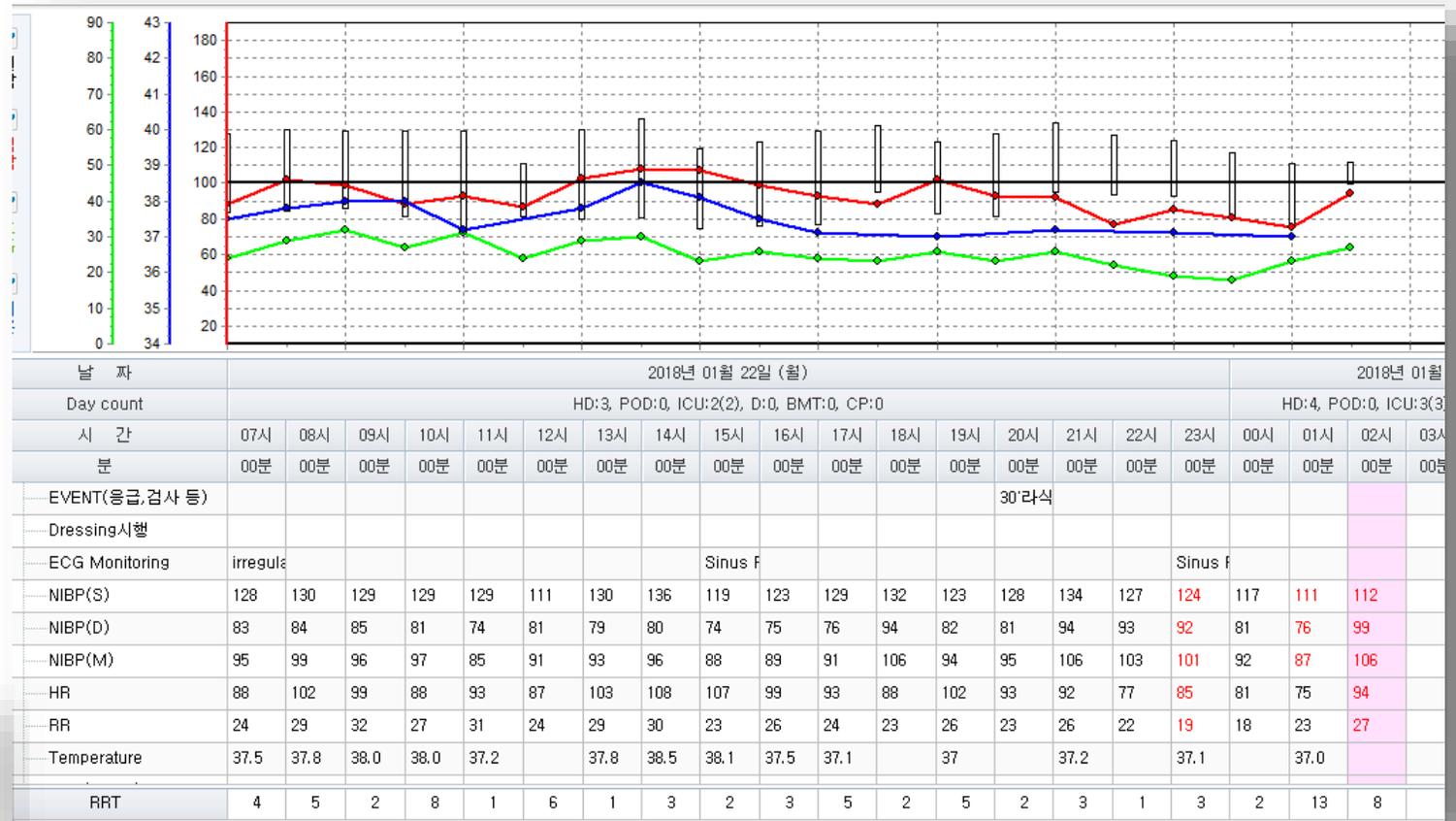


Deep Learning: AEGIS with LSTM



✓ Embedded AI in EMR

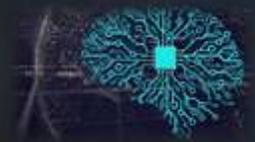
★ Cardiac Arrest Early warning algorithm In Sejong hospital



SCOUT Sejong Critical Care Outreach Team



Deep Learning: AEGIS with LSTM



✓ Embedded AI in EMR



Real time
risk score
calcuation

Alarming
SCOUT(RRT)
With risk score



시 간	07시	08시	09시	10시	11시	12시	13시	14시	15시	16시	17시	18시	19시	20시
Event, 순환기	00분	00분	00분	00분	00분	00분	00분	00분	00분	00분	00분	00분	00분	00분
NIBP(S)						109							129	
NIBP(D)						71							65	
HR						70							70	
RR						16							16	
Temperature						37.8							37.6	
SpO ₂ (%)						96							99	
total output														90
RRT						47								

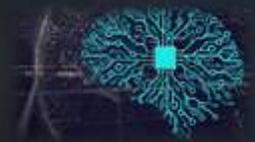
< Vital sign sheet in EHR >

07-24	49	Cerebral infarction	경피경관상형술 ...	46	2017-09-04 06:00:00		
08-30	12	Parkinsonism NOS			2017-09-04 18:00:00	RRT	90
09-05	6	Stable angina	두 카테터를 사...	4	2017-09-06 09:48:33	POST	
09-01	10	Postherpetic neu...			2017-09-05 19:00:00	RRT	90
09-07	4	Stable angina	두 카테터를 사...	3	2017-09-07 15:24:50	POST	
09-03	8	CML, blast crisis			2017-09-03 19:00:00	HR	6
09-05	6	Deep vein throm...	하대정맥 여과	5	2017-09-01 10:40:45	POST	
09-02	9	Perforation of int...			2017-09-03 13:00:00	RR	57
09-01	10	Persistent atrial f...			2017-09-03 07:00:00	HR	45
08-29	13	Obstructive slee...	구개수구개 인두...	11	2017-09-04 06:00:00	RRT	91
08-31	11	Cerebral infarcti...	동맥경류 기계적...	10	2017-09-06 11:00:00		

< Rapid Response System Dashboard >



Thank you for Your Attention



권준명

Joon-myung Kwon

**Chief Director,
Artificial intelligence and big *D*ata *C*enter,
Sejong Medical Research Institute**

**Chief,
Department of Emergency medicine,
Mediplex Sejong Hospital**

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