Ventilator Weaning Assistance System (VWAS)

CS6440 Spring 2021

Xu Shi, Xiaoyang Xia, Xingdan Wang, Kunming Zhu, Chen Hu, Manfred Chan

TA Mentor: Raj Vansia

Project Goals & Requirements

Project Goals

- Based on the literature survey, a practical weaning protocol will be developed
- Machine learning tool will be introduced to predict the possible start of weaning

Requirements

- The final deployed application will be able to collect data from FHIR server and predict the start of weaning process based on patient conditions
- The application will also provide some population level results, such as length of stay in the ICU

Team Roles & Responsibilities

Team Member	Primary Role(s)	Responsibilities
Xu Shi	Project Coordinator, Weaning Protocol Research	Coordinated team meetings, Weaning protocol research, Technical writing and editing, and QA
Xiaoyang Xia	Weaning Protocol Research, Database Developer	Weaning protocol research, Handling FHIR server, Technical writing and documentation
Xingdan Wang	Full Stack Developer, Architect	Lead both the frontend and backend design and development, JS programming, visualization, GitHub deployment
Kunming Zhu	Machine Learning	Lead the machine learning part: model selection, model training, and optimization
Chen Hu	Frontend Developer	Front end design, Data Preparation and Visualization, Update the Gantt charts and other records management
Manfred Chan	Data Generation and Optimization	Lead data generation, reformatting, and optimization for machine learning, Technical writing and editing, and QA

Final Project Timeline & Gantt Chart

Name	Week 8 3/1/2021	Week 9 3/8/2021	Week 10 3/15/2021	Week 11 3/22/2021	Week 12 3/29/2021	Week 13 4/5/2021	Week 14 4/12/2021	Week 15 4/19/2021	Week 16 4/26/2021
Xu Shi	Proposal Preparation	Project Design/Implementation Plan		Weaning Criteria Research		Clinician View Design & Implementation		Final Documentation Preparation	Team Evaluation
Chen Hu	Proposal Preparation	Project Design/Implementation Plan		Weaning Criteria Research		Clinician View Design & Implementation		Test bug fix & Final Presentation	Team Evaluation
Xingdan Wang	Proposal Preparation	Project Design/Implementation Plan		Research on Synthea		Clinician View Design & Implementation		Integration Test & Final Presentation	Team Evaluation
Xiaoyang Xia	Proposal Preparation	Project Design/Implementation Plan		Research on Synthea		Population View Design & FHIR Server Connection		Data Upload	Team Evaluation
Kunming Zhu	Proposal Preparation	Project Design/Implementation Plan		Algorithm Selection		Population Health View Design & Implementation & Testing		Test bug fix & Final Presentation	Team Evaluation
Manfred Chan	Proposal Preparation	Project Design/Implementation Plan		Algorithm Selection		Artificial Patient Data Generation	Testing	Integration Test & Final Presentation	Team Evaluation

Motivation

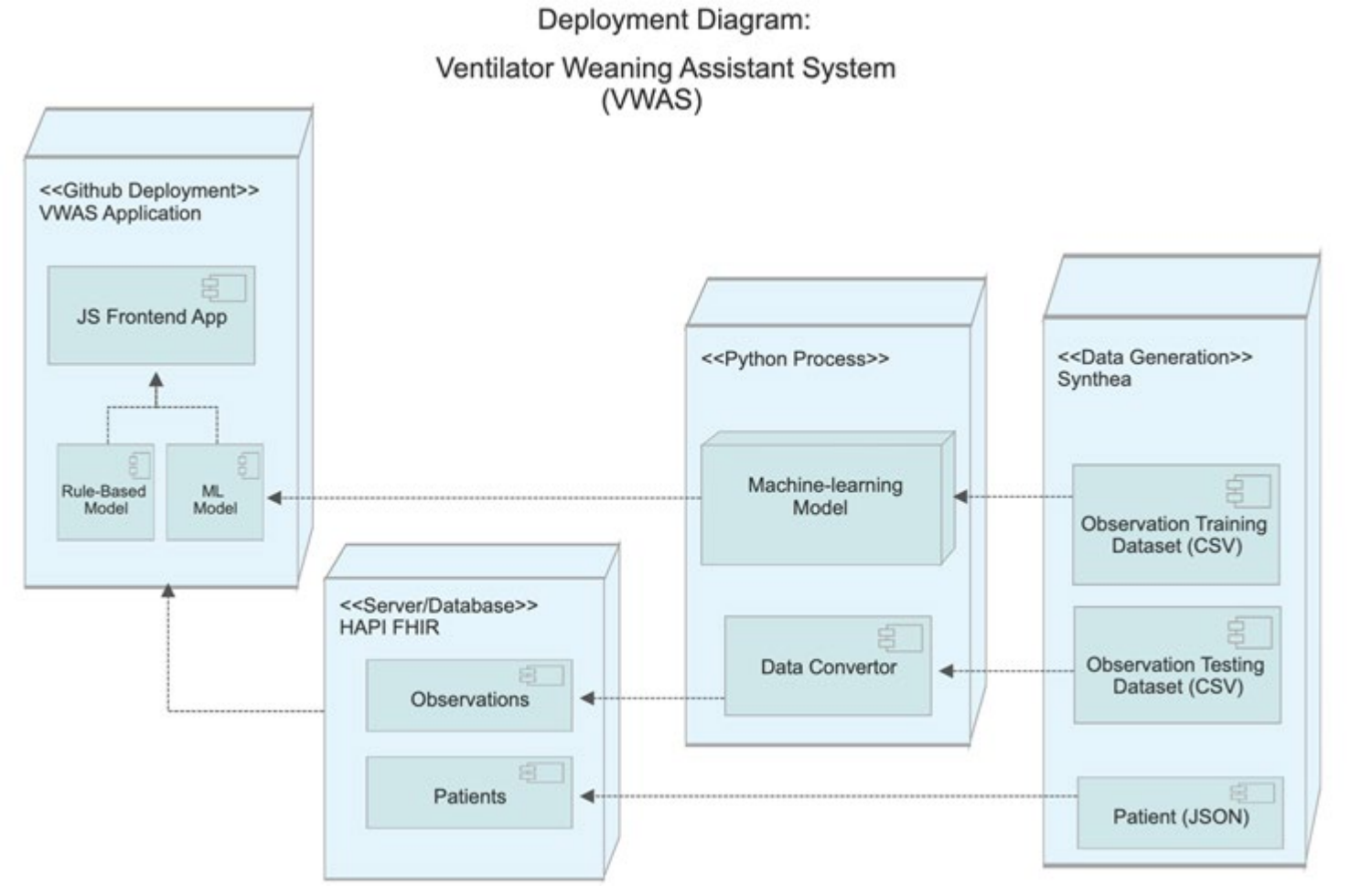
Short of Availability

- No webapp available for providing ventilator weaning recommendations.
- Self-evolving weaning recommendation system are attractive and necessary.

Lack of Efficiency

- Current ventilator weaning protocol is very inefficient.
- Efficient use of ventilators, including weaning ventilator in time and reallocating them to patients in need, could lower mortality and increase comfortability of patient.

Architectural Design



Synthetic patient data generated by Synthea COVID-19 module with R4 FHIR standard

Synthea patient data are uploaded to public FHIR server:

- http://hapi.fhir.org/baseR4
- server name: UNH_HAPI SERVER (R4 FHIR)

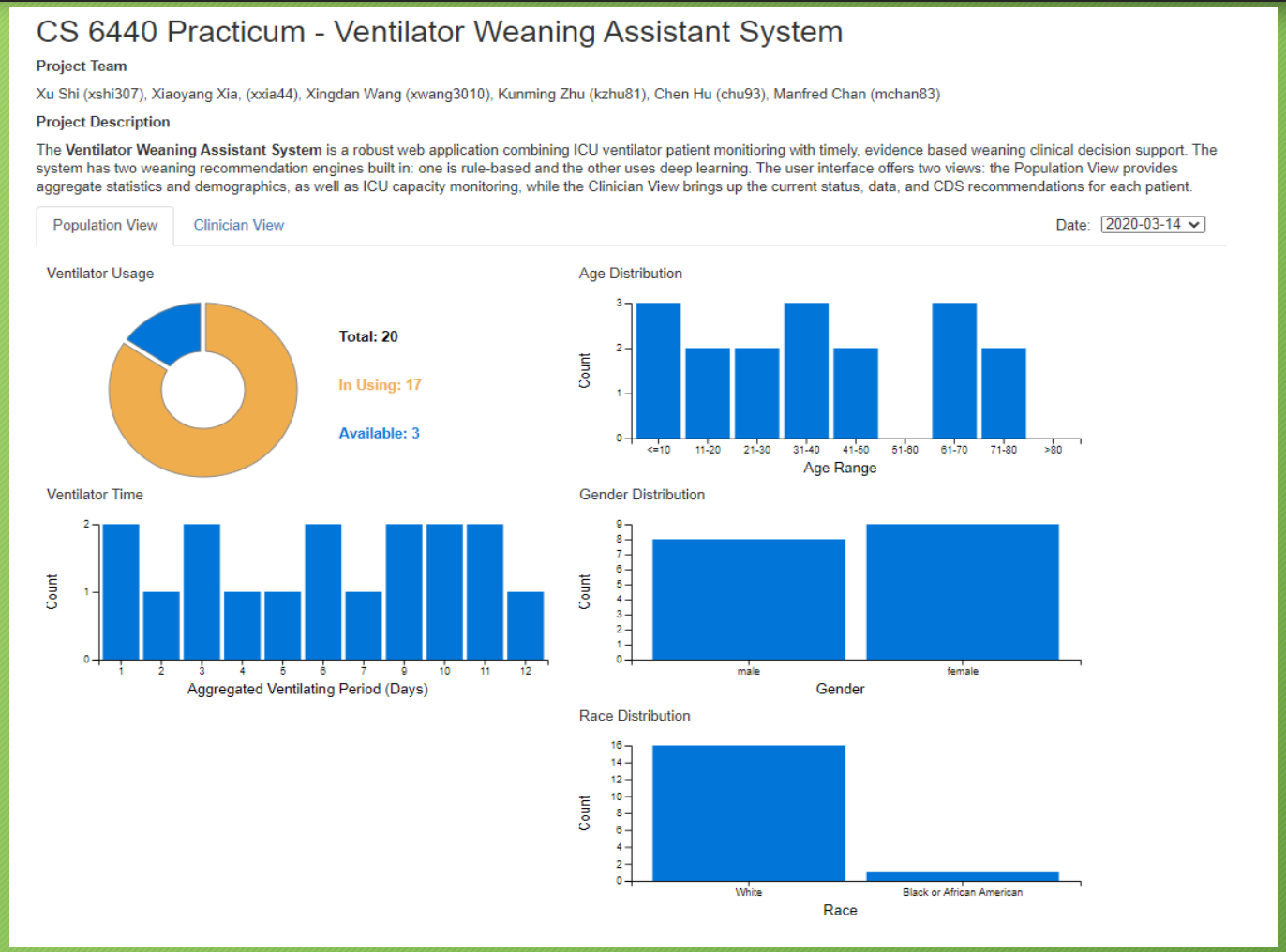
Wean Protocol

#	Name	Unit	Range ready to weaning	Notes
1	Systolic BP	mmHg	90-180	Systolic Blood Pressure Observation (LOINC = 55284-4, 8480-6)
2	Arterial pH	--	≥ 7.25	Art pH Observation (LOINC =2744-1)
3	Arterial O2 Saturation/SpO2	--	≥ 92%	SpO2 Observation (LOINC = 2714-4)
4	FiO2	%	≤ 50	FiO2 Observation (LOINC = 19994-3)
5	PEEP	cm H2O	≤ 5	Positive end expiratory pressure setting Ventilator (LOINC 20077-4)
6	Heart Rate	/min	≤ 130	

Machine Learning Model

- Easily identifies trends and patterns
- No human Intervention is needed
- Continuous Improvement
- Convolutional neural network (CNN) model is selected which will tolerate more complexed real datasets in the future
- Based on the analysis of the model, 95% accuracy can be achieved based on the artificial datasets

Population View

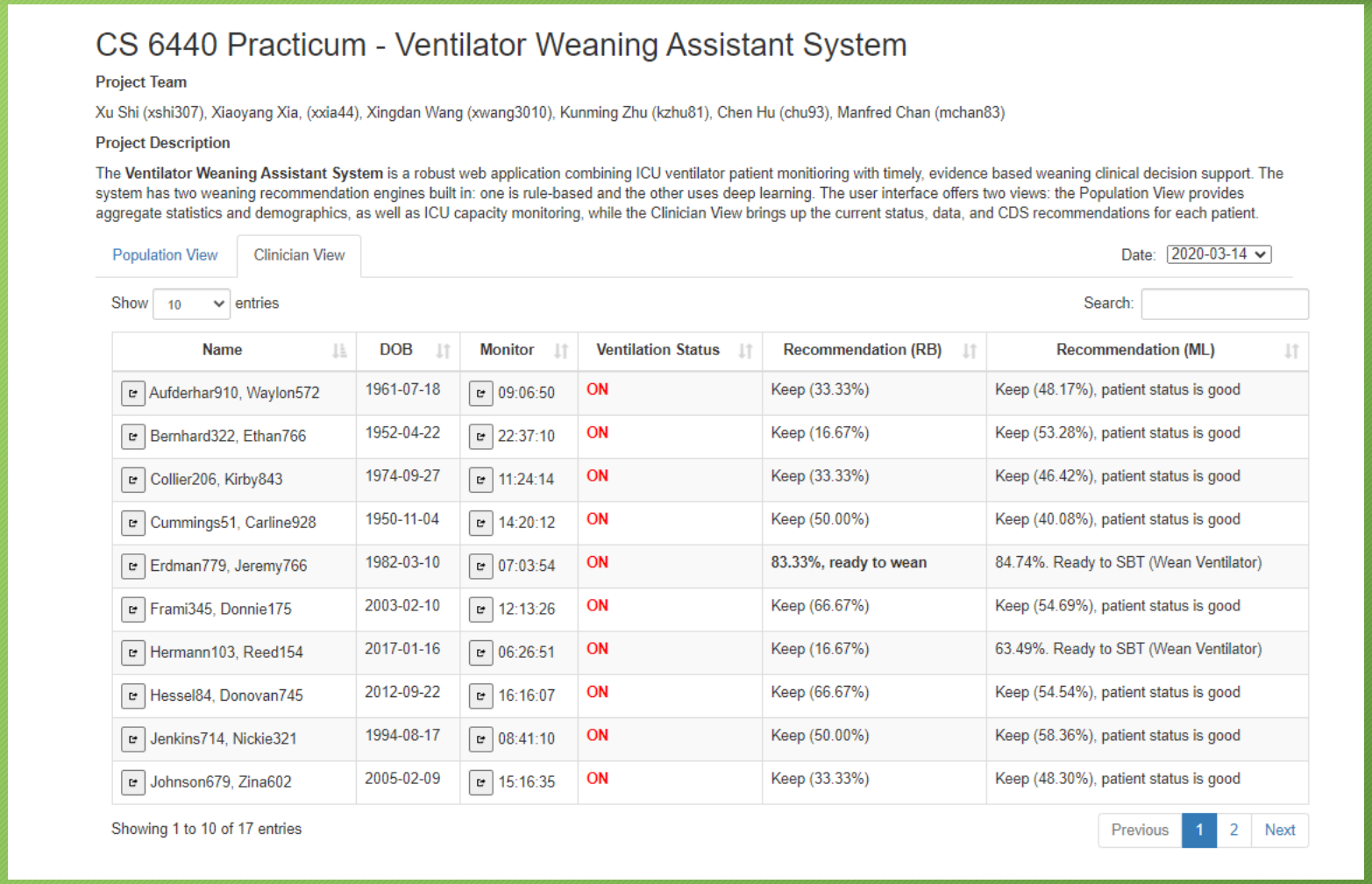


Based on the artificial patients information, ventilator usage can be tracked

Patient average time on the ventilator can also be plotted and automatically updated when you refresh the data

Other information, such as age distribution, gender distribution, race distribution of patients can also be provided. Population view can be modified based on the user request

Clinical View



CS 6440 Practicum - Ventilator Weaning Assistant System

Project Team

Xu Shi (xshi307), Xiaoyang Xia, (xxia44), Xingdan Wang (xwang3010), Kunming Zhu (kzhu81), Chen Hu (chu93), Manfred Chan (mchan83)

Project Description

The **Ventilator Weaning Assistant System** is a robust web application combining ICU ventilator patient monitioring with timely, evidence based weaning clinical decision support. The system has two weaning recommendation engines built in: one is rule-based and the other uses deep learning. The user interface offers two views: the Population View provides aggregate statistics and demographics, as well as ICU capacity monitoring, while the Clinician View brings up the current status, data, and CDS recommendations for each patient.

Population View | Clinician View

Date: 2020-03-14

Show 10 entries

Search:

Name	DOB	Monitor	Ventilation Status	Recommendation (RB)	Recommendation (ML)
Aufderhar910, Waylon572	1961-07-18	09:06:50	ON	Keep (33.33%)	Keep (48.17%), patient status is good
Bernhard322, Ethan766	1952-04-22	22:37:10	ON	Keep (16.67%)	Keep (53.28%), patient status is good
Collier206, Kirby843	1974-09-27	11:24:14	ON	Keep (33.33%)	Keep (46.42%), patient status is good
Cummings51, Carline928	1950-11-04	14:20:12	ON	Keep (50.00%)	Keep (40.08%), patient status is good
Erdman779, Jeremy766	1982-03-10	07:03:54	ON	**83.33%, ready to wean**	84.74%. Ready to SBT (Wean Ventilator)
Frami345, Donnie175	2003-02-10	12:13:26	ON	Keep (66.67%)	Keep (54.69%), patient status is good
Hermann103, Reed154	2017-01-16	06:26:51	ON	Keep (16.67%)	63.49%. Ready to SBT (Wean Ventilator)
Hessel84, Donovan745	2012-09-22	16:16:07	ON	Keep (66.67%)	Keep (54.54%), patient status is good
Jenkins714, Nickie321	1994-08-17	08:41:10	ON	Keep (50.00%)	Keep (58.36%), patient status is good
Johnson679, Zina602	2005-02-09	15:16:35	ON	Keep (33.33%)	Keep (48.30%), patient status is good

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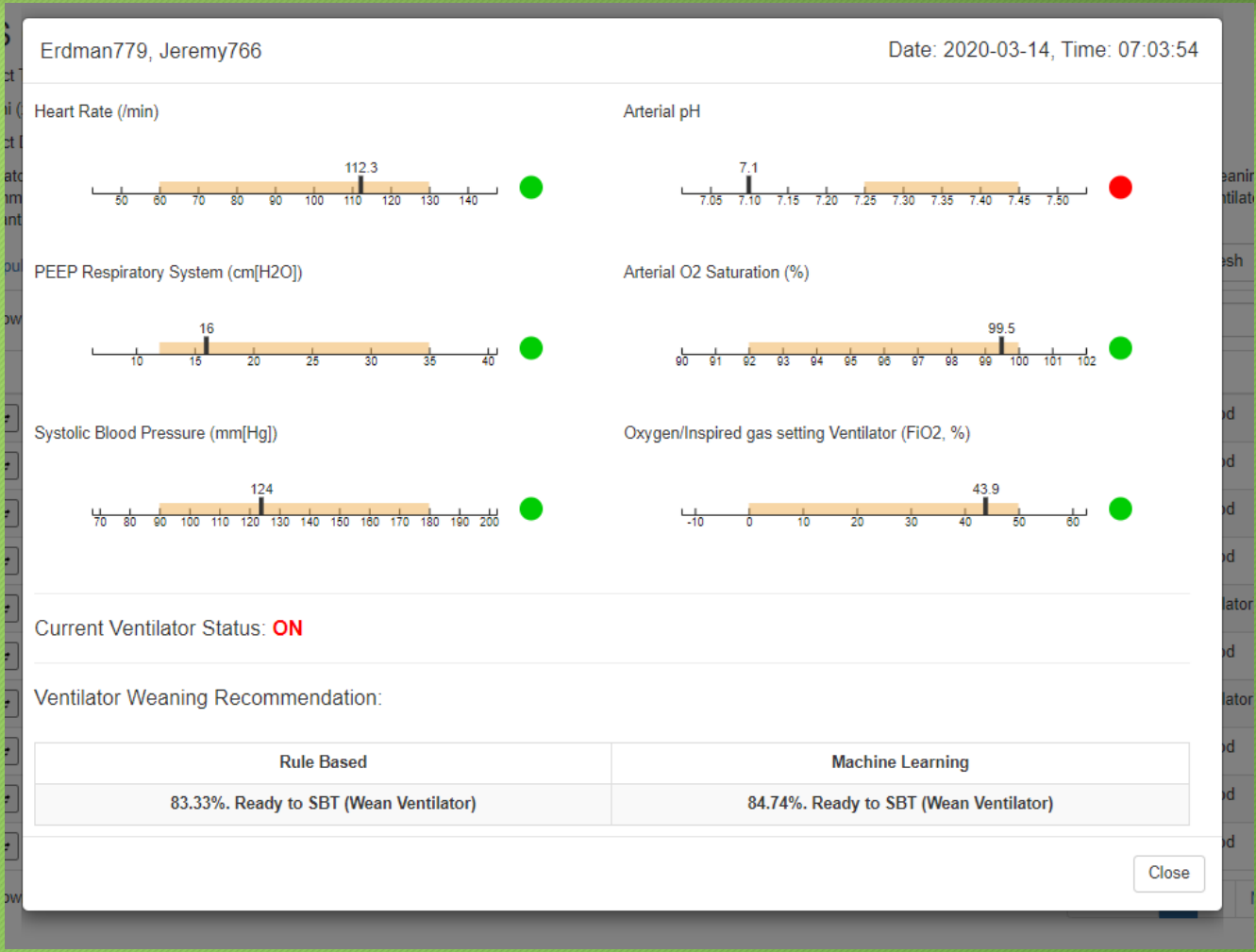
In Clinician View, all the patients currently on ventilator are listed

You could check each patient's information and vital signs

Rule-based and ML-based Recommendation are provided

ML-based model will also predict the condition of the patient

Clinical View



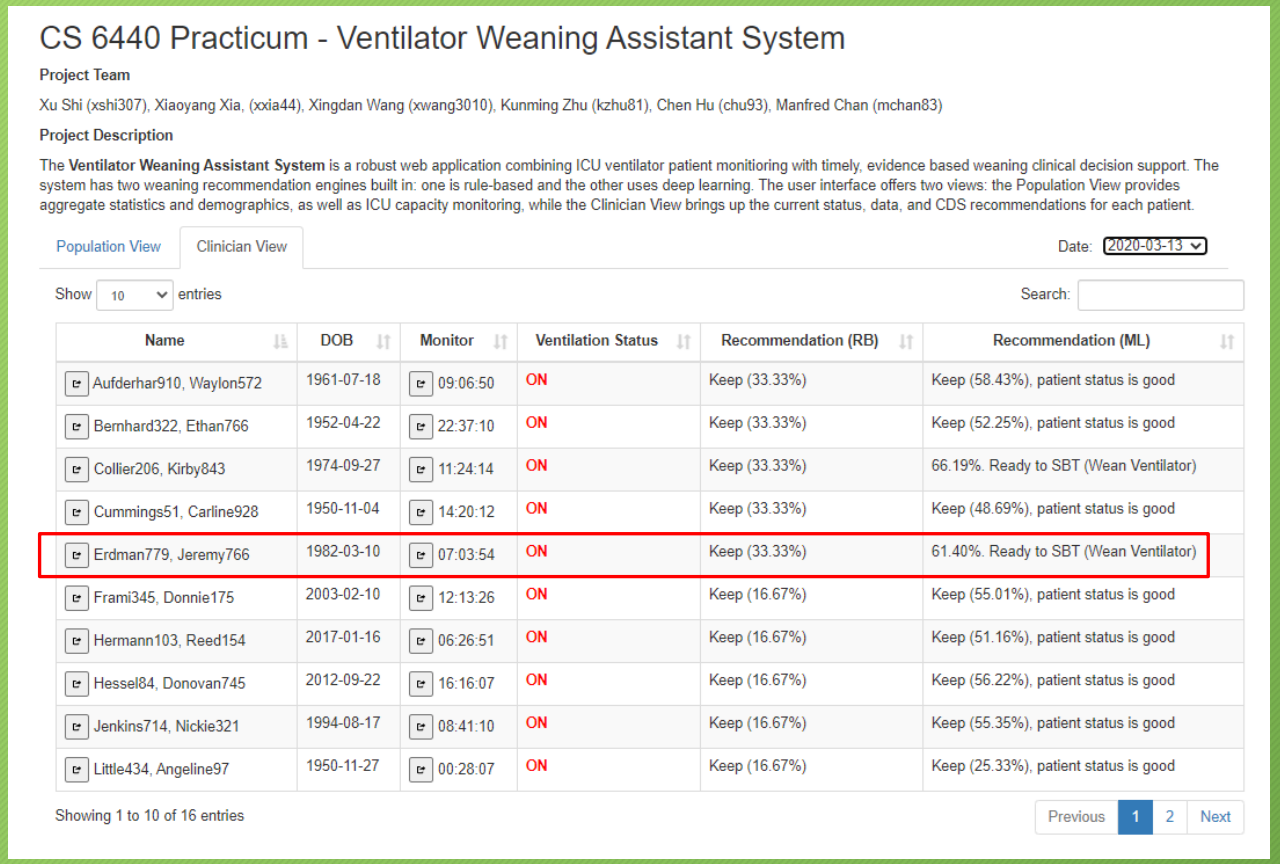
Detailed information regarding the patients vital signs

Normal range for each vital sign is also provided

Based on the ML model, this patient is ready to start the weaning process

Machine learning and rule based model both predict the same thing, final decision will be made by the doctor

Data Refresh



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Date: 2020-03-13

Show 10 entries Search:

Name	DOB	Monitor	Ventilation Status	Recommendation (RB)	Recommendation (ML)
Aufderhar910, Waylon572	1961-07-18	09:06:50	ON	Keep (33.33%)	Keep (58.43%), patient status is good
Bernhard322, Ethan766	1952-04-22	22:37:10	ON	Keep (33.33%)	Keep (52.25%), patient status is good
Collier206, Kirby843	1974-09-27	11:24:14	ON	Keep (33.33%)	66.19%. Ready to SBT (Wean Ventilator)
Cummings51, Carline928	1950-11-04	14:20:12	ON	Keep (33.33%)	Keep (48.69%), patient status is good
Erdman779, Jeremy766	1982-03-10	07:03:54	ON	Keep (33.33%)	61.40%. Ready to SBT (Wean Ventilator)
Frami345, Donnie175	2003-02-10	12:13:26	ON	Keep (16.67%)	Keep (55.01%), patient status is good
Hermann103, Reed154	2017-01-16	06:26:51	ON	Keep (16.67%)	Keep (51.16%), patient status is good
Hessel84, Donovan745	2012-09-22	16:16:07	ON	Keep (16.67%)	Keep (56.22%), patient status is good
Jenkins714, Nickie321	1994-08-17	08:41:10	ON	Keep (16.67%)	Keep (55.35%), patient status is good
Little434, Angeline97	1950-11-27	00:28:07	ON	Keep (16.67%)	Keep (25.33%), patient status is good

Showing 1 to 10 of 16 entries

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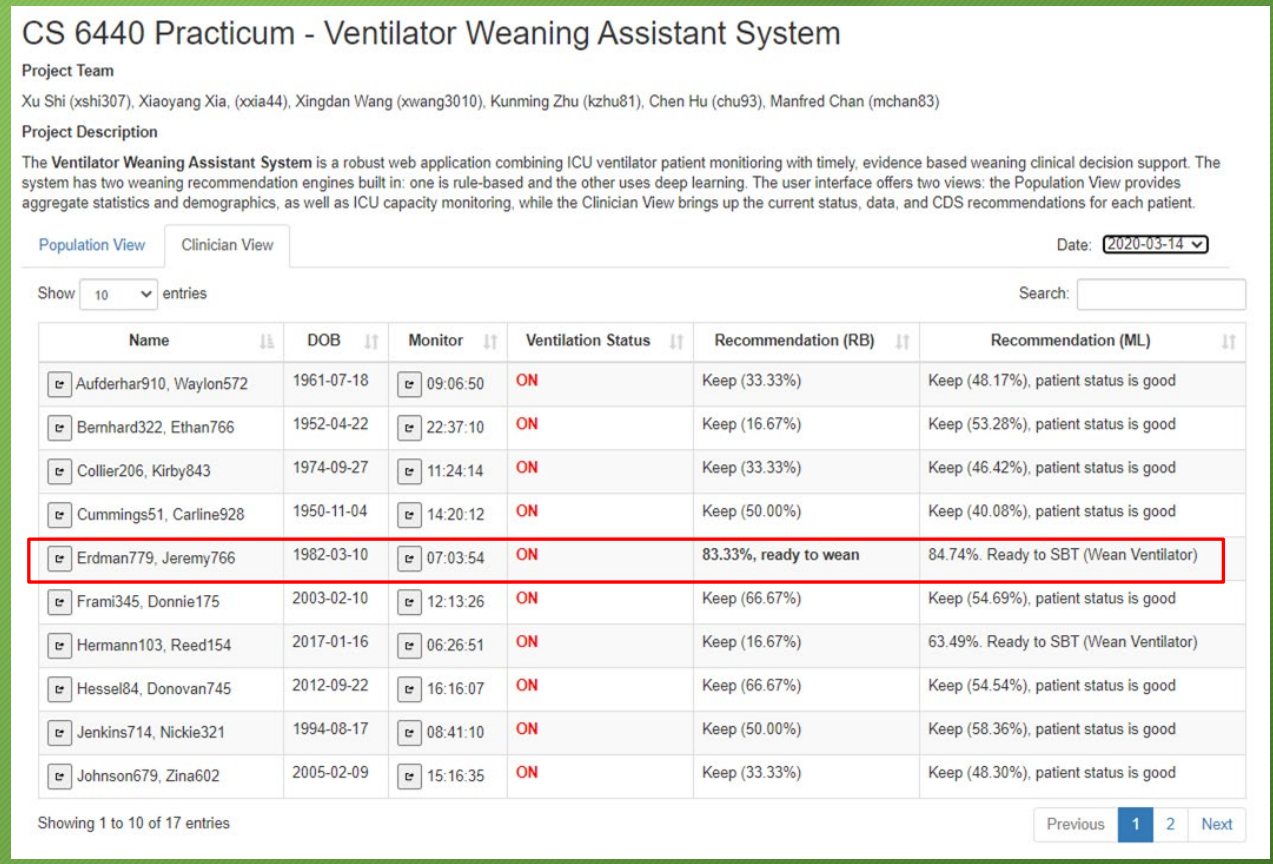

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Showing 1 to 10 of 17 entries

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After choose a different data, new vital signs will be read and new prediction will be provided accordingly

Future Plans and Opportunities

- CDS Hooks
- Improve Visualization
- Upgrade based on the user feedback
- Sub-module for specific diseases