November 2021

Machine Learning and Compressive Sensing for Intensive Care Unit Biomedical Recording Activities

Gelar Budiman, Khairul Anwar
AICOMS Telkom University

OUTLINE

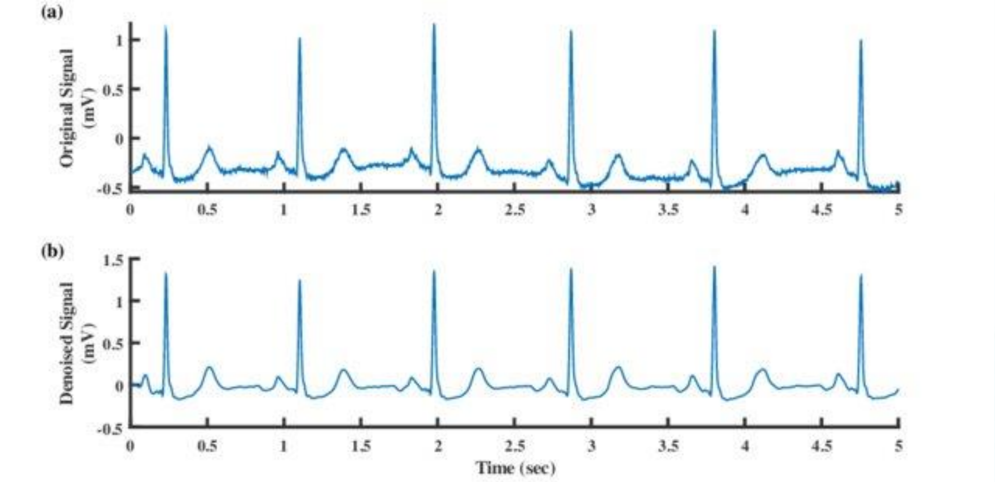
- Background
- Type of Patient’s Biomedical Signal
- Biomedical and multimedia signals to be recorded and analyzed
- Compressed Sensing (CS)
- CS Requirements
- Sparsity
- CS Reconstruction
- CS and Machine Learning
- CS and Machine Learning Requirements

Background

- Many types of biomedical signal produced, including video and audio
- The signals are monitored and recorded for hospital's documentation
- The patient's status is transmitted to the nurse's center
- Storage needs with big capacity
- Patient's prediction status according to the biomedical record

Type of Patient's Biomedical Signal

- Electrocardiograph (ECG) signal
- Arterial Blood Pressure (ABP) signal
- Central Venous Pressure (CVP) signal
- Peripheral Oxygen Saturation (SpO2)
- Heart Rate signal
- Patient's Conditions on Audio Signal
- Patient's Conditions on Video Signal



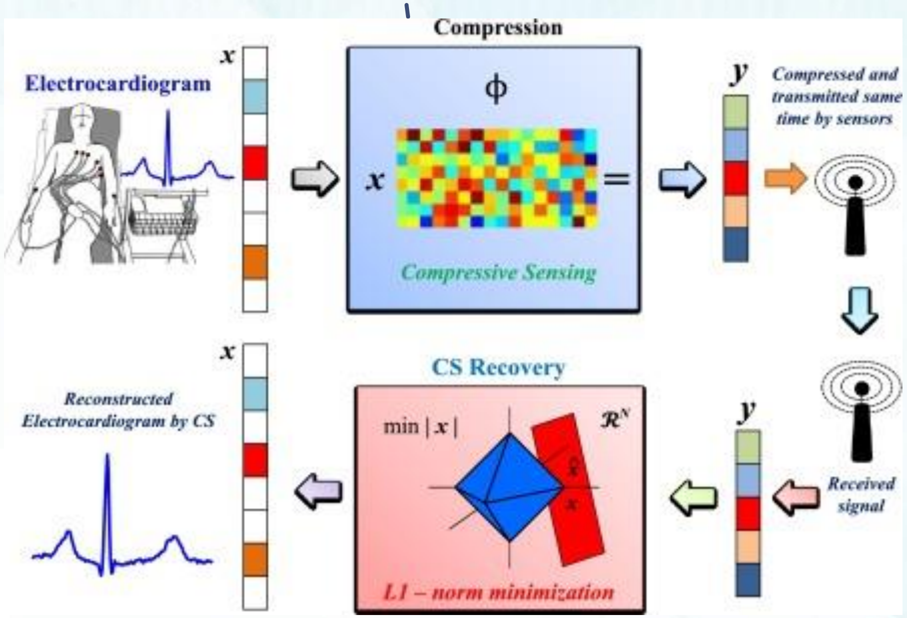
Biomedical and multimedia signals to be recorded and analyzed

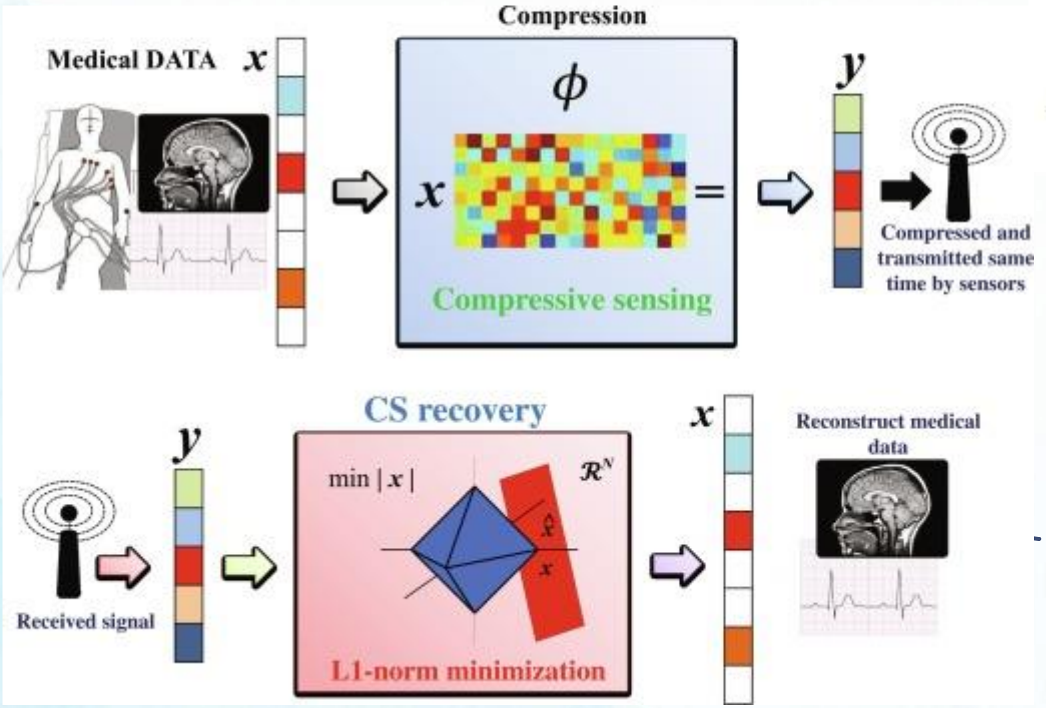
- 1D Signal (16 bits per sample)
  - Electrocardiograph (ECG) signal (0.5 kHz)
  - Arterial Blood Pressure (ABP) signal (0.2 kHz)
  - Central Venous Pressure (CVP) signal (0.4 kHz)
  - Peripheral Oxygen Saturation (SpO2) (0.1 kHz)
  - Heart Rate (HR) signal (1 kHz)
  - Patient's Conditions on Audio Signal (Single channel audio, 9.6 kHz)
- 2D Signal (RGB, 8 bit per pixel)
  - Patient's Conditions on Video Signal (RGB, 600x400, 30 fps)

Compressive Sensing (CS)

$$y_{M\times 1} = \phi_{M\times N} x_{N\times 1}, \qquad M < N$$

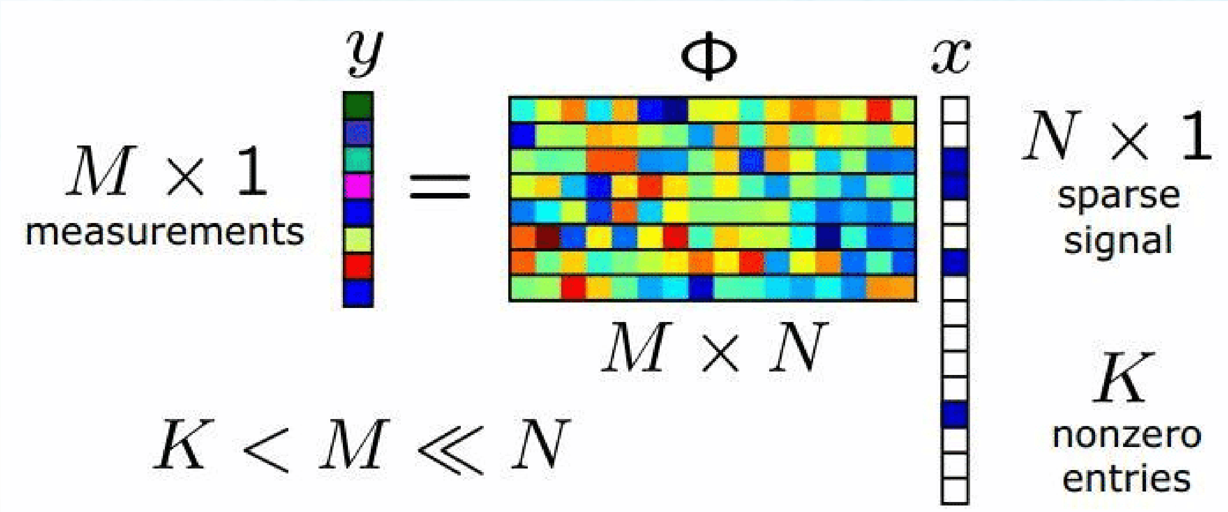
$$\hat{x} = \min \ \|x\|_0 \ \text{ subject to } y = \phi x$$





CS Requirements

Sparse Signal Input



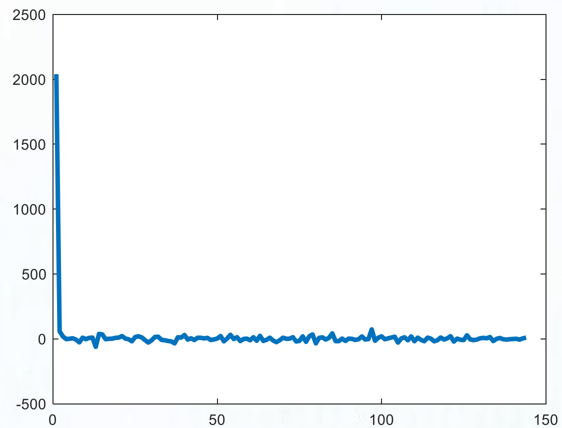
Restricted Isometric Property

$$(1-\delta_s)\|x\|_2 \leq \|\phi x\|_2 \leq (1+\delta_s)\|x\|_2$$

ϕ is an M×N generated random matrix with certain distribution

δ_s is a constant containing small positive value

Compressible



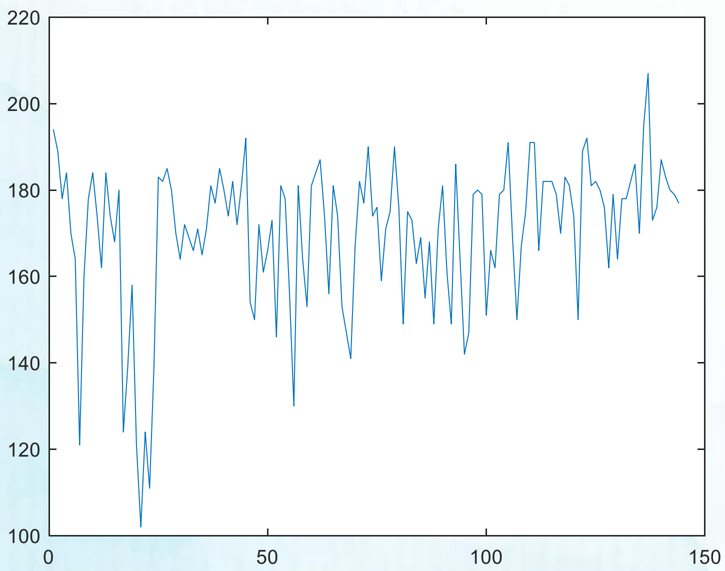
Sparsity

194	184	183	181	161	184	190	169	179	175	150	182
189	174	182	177	166	187	174	155	180	191	189	186
178	168	185	185	173	174	176	168	179	191	192	170
184	180	180	180	146	156	159	149	151	166	181	195
170	124	170	174	181	181	171	171	166	182	182	207
164	139	164	182	178	174	175	181	162	182	180	173
121	158	172	172	156	153	190	161	179	182	176	176
160	121	169	181	130	147	176	149	180	179	162	187
178	102	166	192	181	141	149	186	191	170	179	183
184	124	171	154	164	167	175	164	169	183	164	180
174	111	165	150	153	182	173	142	150	181	178	179
162	139	171	172	181	177	163	147	167	174	178	177

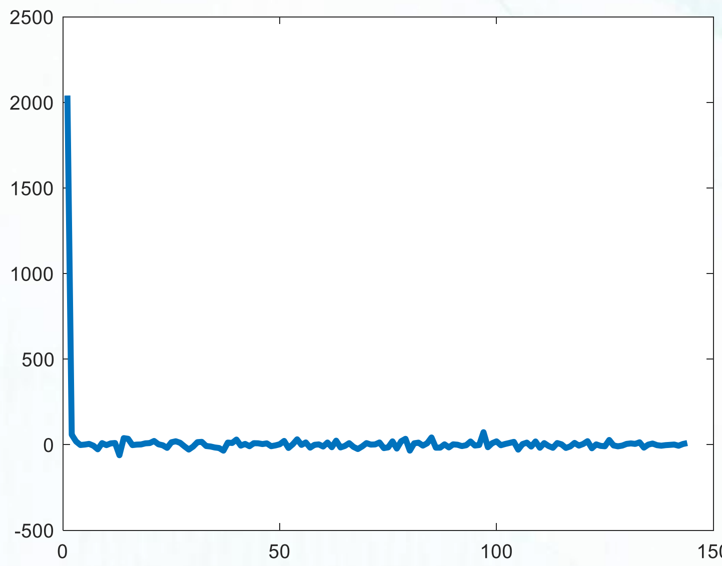
DCT 2D

2040	-62	14	-35	-4	13	13	42	73	19	20	14
58	38	20	12	3	-15	-20	-17	-15	-18	-21	-17
19	34	11	10	22	23	-16	-17	9	9	2	0
-2	-2	-10	30	-19	-16	19	2	19	-8	-7	7
1	1	-29	-5	3	-7	-23	-16	-3	-18	-9	-3
5	2	-11	5	31	9	20	2	4	10	28	-6
-6	8	15	-9	-1	-13	34	0	10	2	-4	-3
-27	9	17	9	13	-25	-35	-8	16	-19	-10	-1
9	22	-8	8	-17	-10	8	-3	-29	-10	-5	1
-3	2	-10	4	-1	9	12	19	4	10	4	-6
8	-3	-16	8	2	1	-5	-5	12	-5	8	4
10	-19	-19	-9	-11	2	8	-2	-11	4	4	10

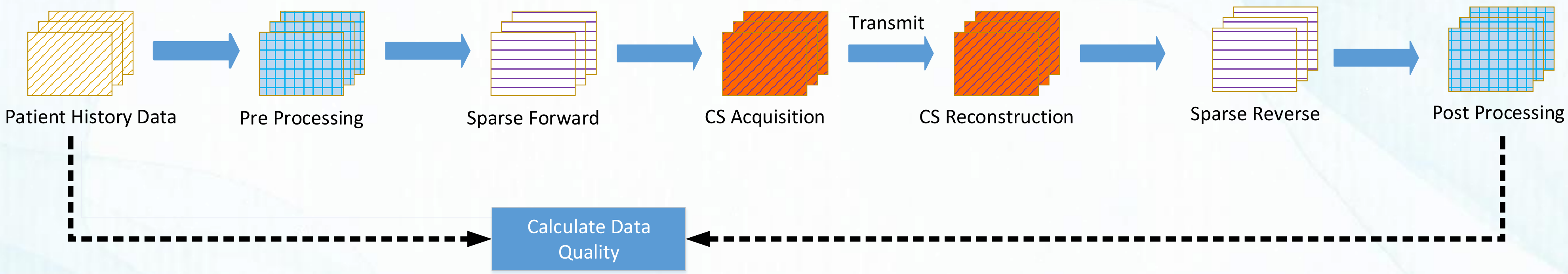
2D to 1D



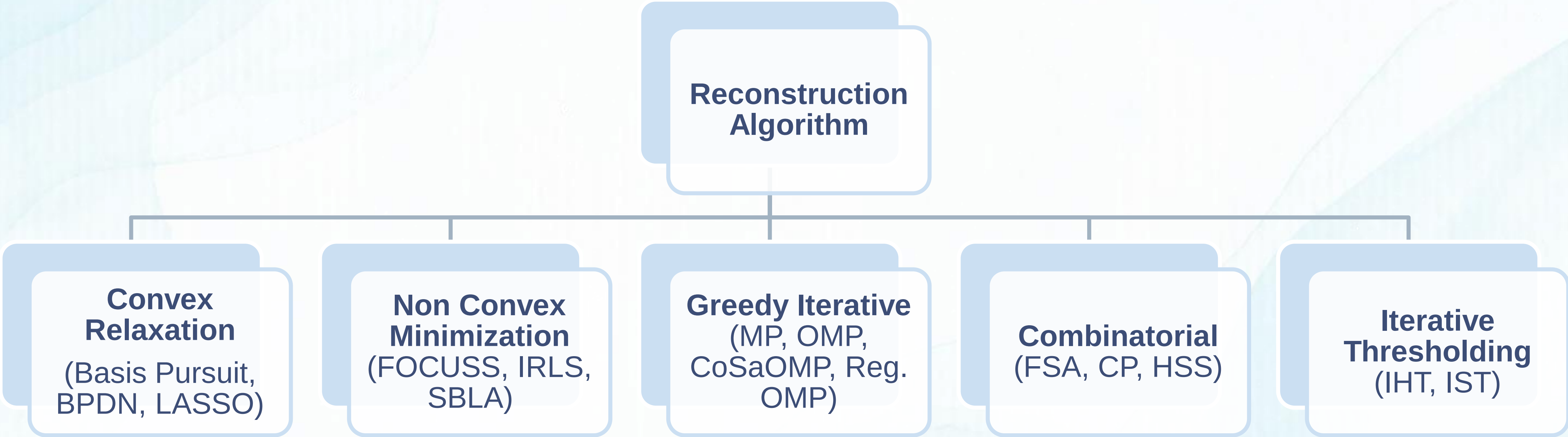
2D to 1D



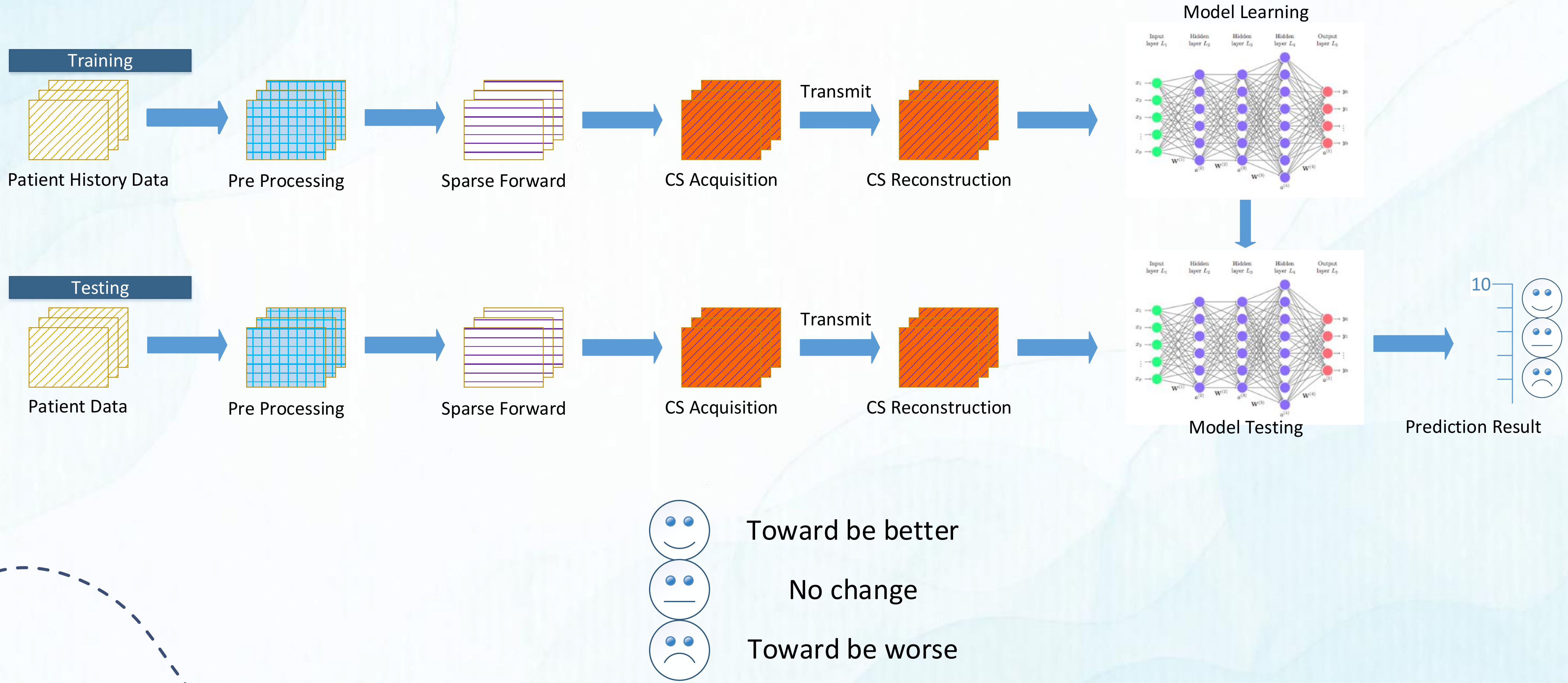
CS complete stage, acquisition-reconstruction



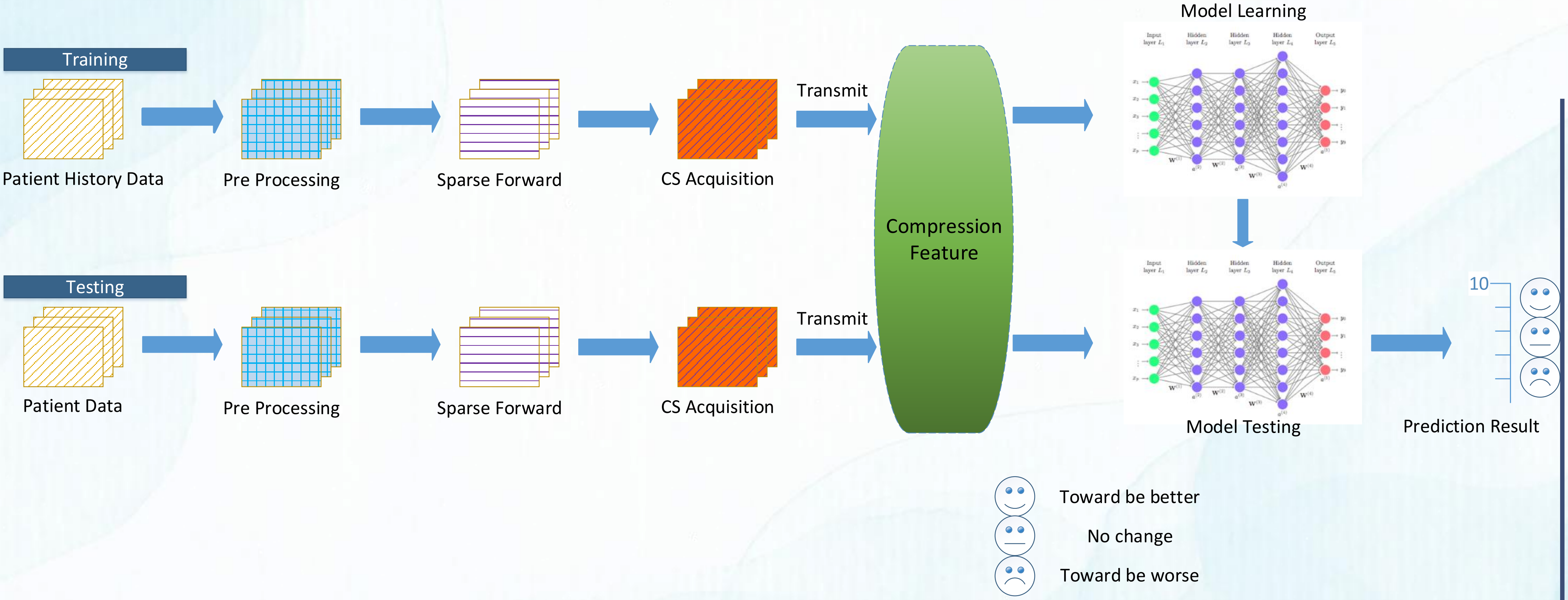
CS Reconstruction



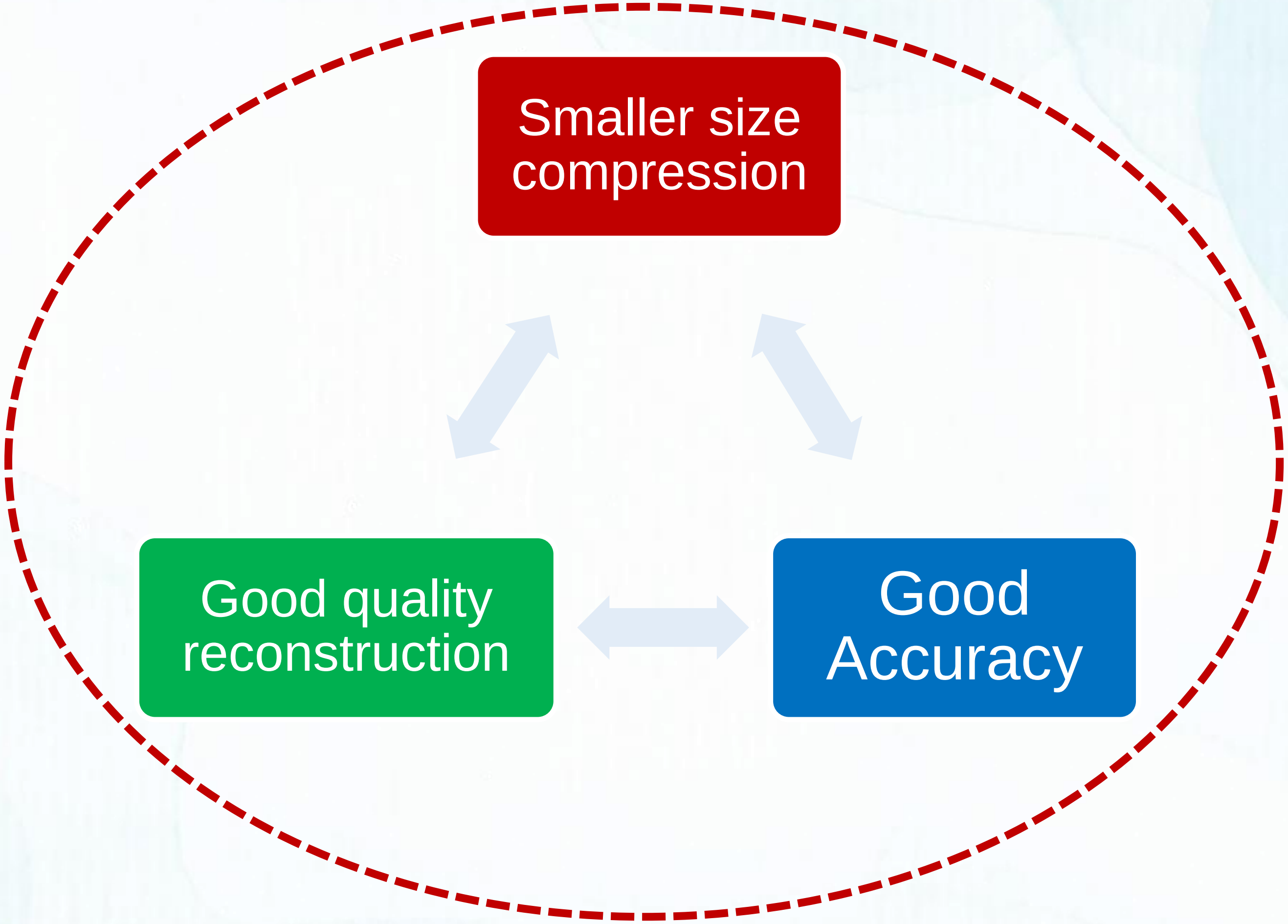
CS and Machine Learning (Scheme 1)



CS and Machine Learning (Scheme 2)



CS and Machine Learning Requirements



Conclusion

- We propose applying CS to the patients biomedical data in ICU before the data is transmitted to the server
- Applying CS will reduce the size of biomedical data, thus obtaining more efficient storage
- Applying CS will also reduce the bandwidth needs
- Sparse features of the biomedical data are used for training by machine learning in the training phase
- In the testing process, the sparse features of the biomedical data will be classified/predicted into patient category, to be better, no change, and to be worse.

Thank you!

AICOMS

CREDITS: This presentation template was created by Slidesgo, including icons by Flaticon and infographics & images by Freepik