Making improved predictions of Non-invasive Continuous Arterial Blood Pressure through leveraging EHR medication data

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Background

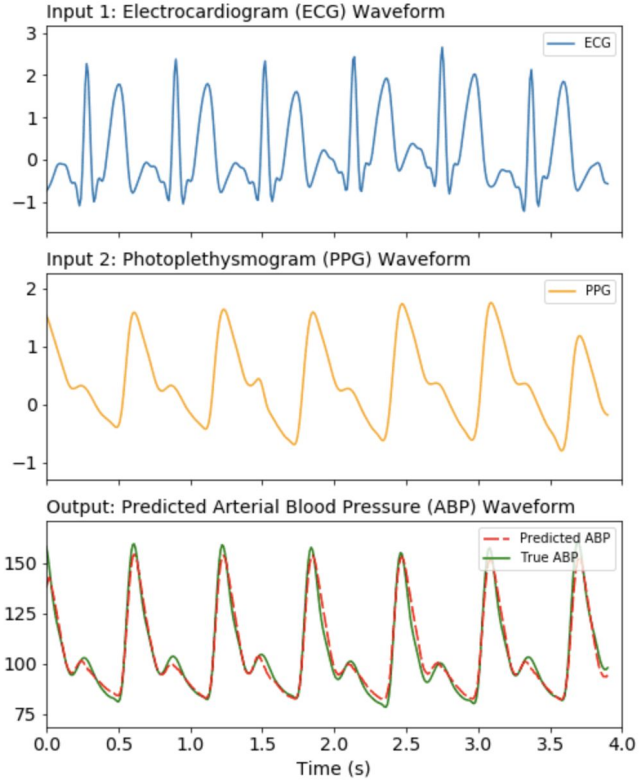
Non-invasive non-continuous blood pressure measurements

Invasive **continuous** blood pressure measurements

?

There exists a computational tool that can predict ABP non-invasively and continuously

ABPImputation Package



Hill, B.L., Rakocz, N., Rudas, Á. et al. Imputation of the continuous arterial line
blood pressure waveform from non-invasive measurements using deep learning. Sci Rep 11, 15755 (2021). https://doi.org/10.1038/s41598-021-94913-y

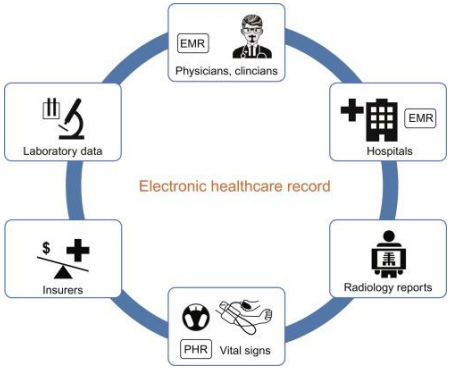
Table 2. RMSE table

Method	MIMIC	UCLA
PPG scaling	6.895 (6.876–6.914)	9.108 (9.078–9.137)
Sideris et al	13.940 (13.901–13.978)	13.111 (13.072–13.151)
1D V-Net	5.823 (5.806–5.840)	6.961 (6.937–6.985)

Table 2. Root mean square error (mean (95% CI)) for each cohort.

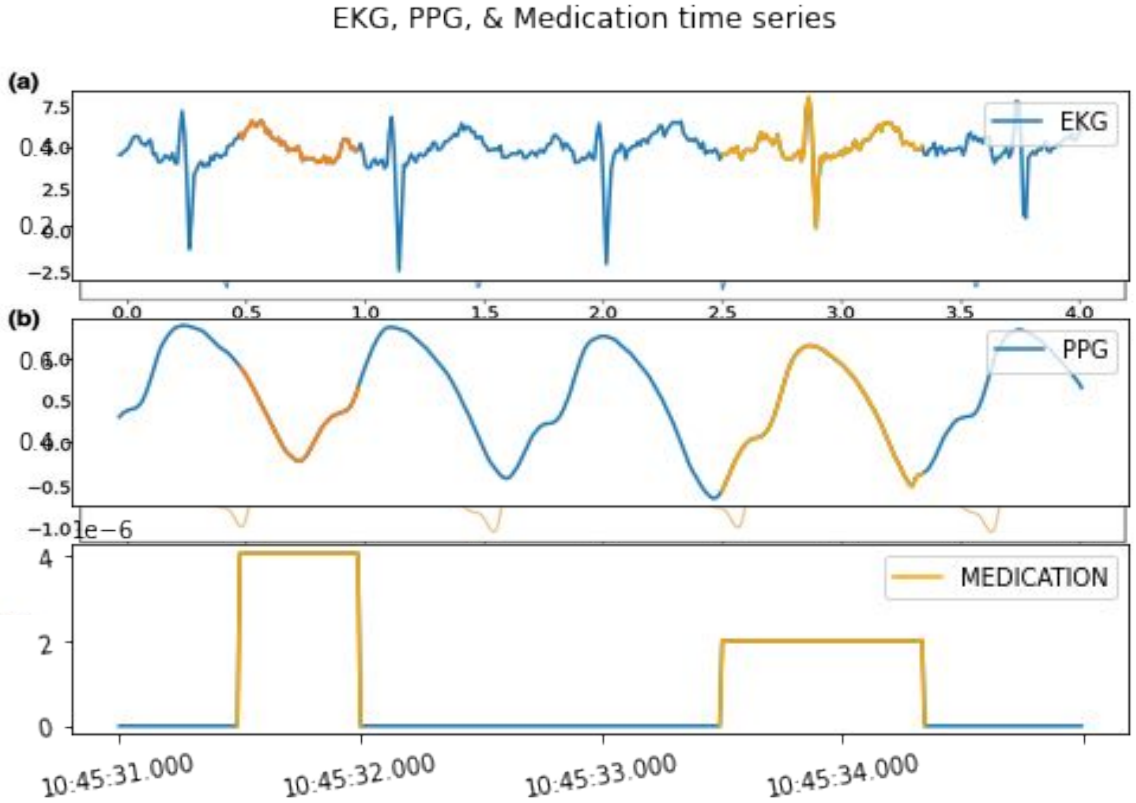
Predictions are pretty good! but can always be better!

How can we make predictions better



Pressor	Receptor	Initial Dose	Notes
Norepinephrine	α > β	7 mcg/min	Bees knees
Epinephrine	β > α	5 mcg/min	More ionotropy. Consider 5mcg/min + norepi
Vasopressin	V_1	0.03 U/min	Fixed dose, no titration
Phenylephrine	α	30 mcg/min	Good for tachy hearts
Dopamine	D → β → α	5 - 10 mcg/kg/min	Low dose for stable bradycardia
Dobutamine	β	2.5mcg/kg/min	Poor mans milrinone. Ionotropy alone
Milrinone	PDEi*	0.25mcg/kg/min	Bridge to transplant. Ionotropy + vasodilation
Methylene Blue	NOi, GCi*	1 – 2 mg/kg bolus	Alright Dr. Smarty-pants
Angiotensin II	ATII-R	20ng/kg/min	Alright Dr. Money-bags

Our Input Data

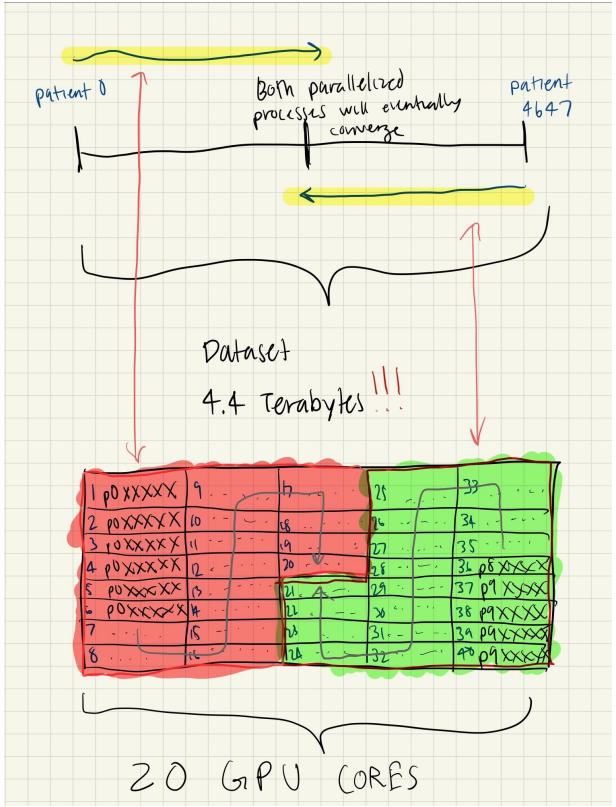


Data Scraping (much of my summer…)

LOGIC FLOW

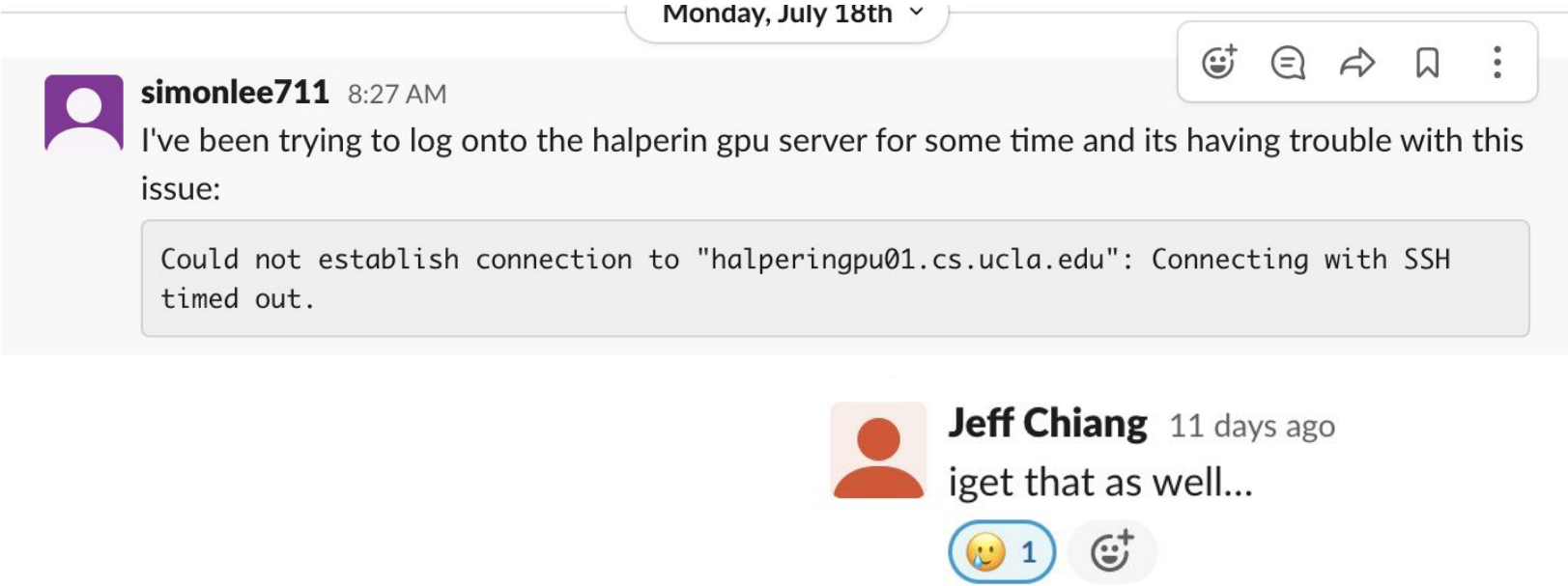
1. Read `D_items.csv` to extract vasopressor drug ID's
2. Filter `INPUTEVENTS_MV.csv` for only patients who recieved vasopressors
3. Scrape the amount of drug administered
4. Calculate in milliseconds, the administration rate
5. Glob.glob the specific patient files
6. Go to `p0XXXXXX.csv.gz` (patient file) and build 5 zero columns for the vasopressor features
7. Match the drugs that were administered to the corresponding columns of the patient file
8. Find start and end time and fill in the rate
9. Write out csv with new drug columns (Most painful part)

Optimization via parallel processing



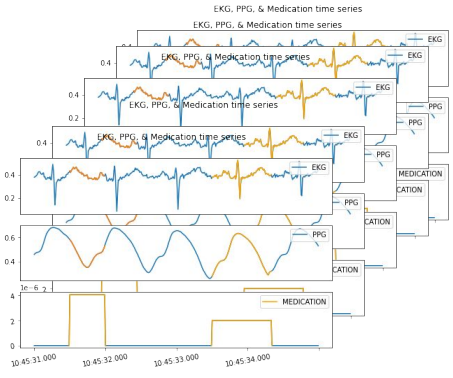
1. Start at the start and end of patient list
2. Allocate 10 gpu cores each and begin writing out csv files with new drug columns
3. Big Idea is widely inspired by TV show “Silicon Valley” - middle out compression algorithm

Complications along the way…



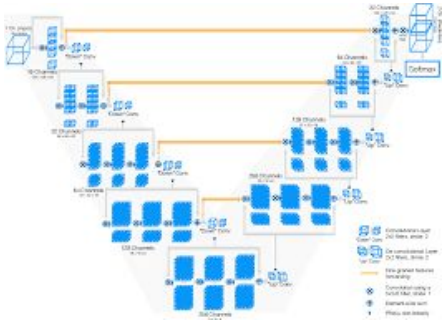
I ended up crashing the halperin gpu server because of exceeding RAM capabilities. But finally generated my enormous dataset

Model

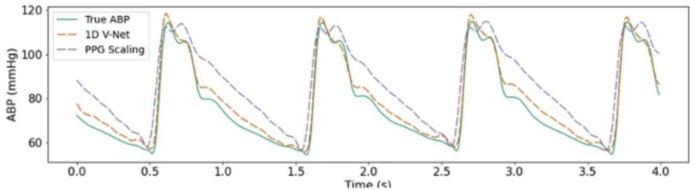


Waveform inputs

FILTERING
By meeting some threshold values



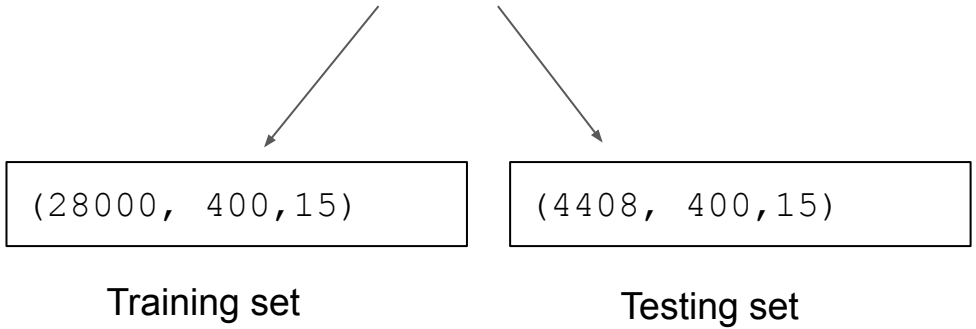
Feed to 1D- Vnet Deep learning architecture

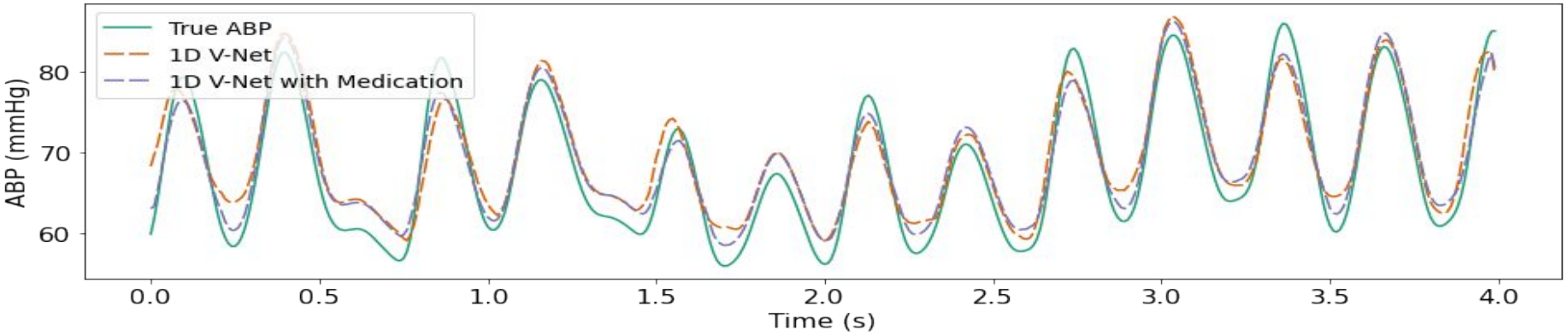


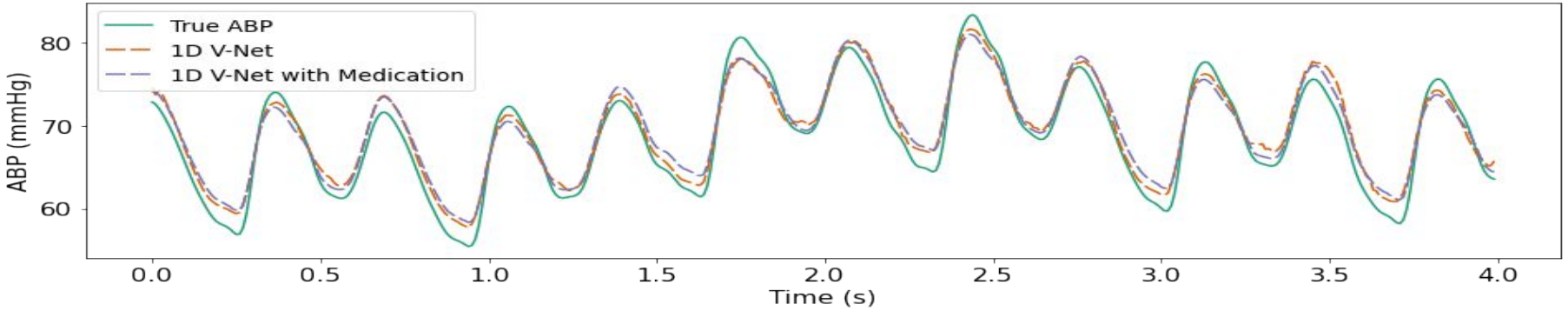
Results

Current Patient sample

- 1 Patient
  - Split into training frame and testing frames
  - (32408, 400, 15)




True ABP
1D V-Net
1D V-Net with Medication
ABP (mmHg)
80
70
60
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Time (s)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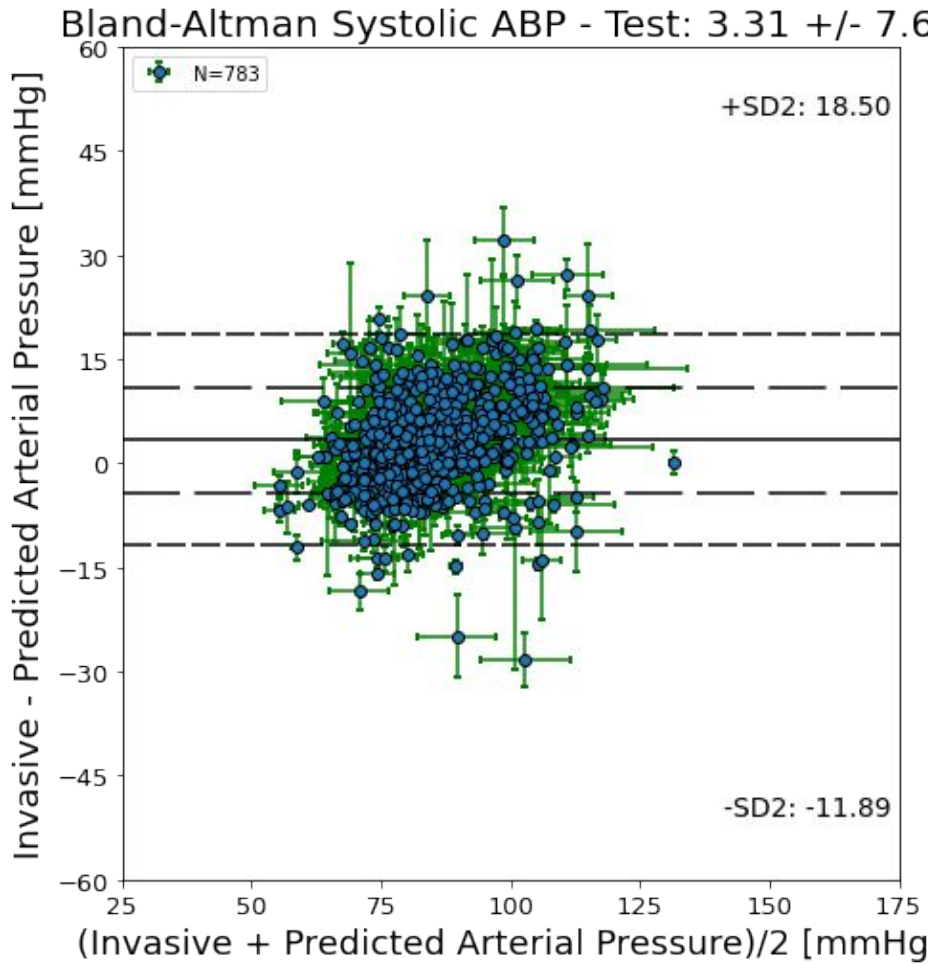
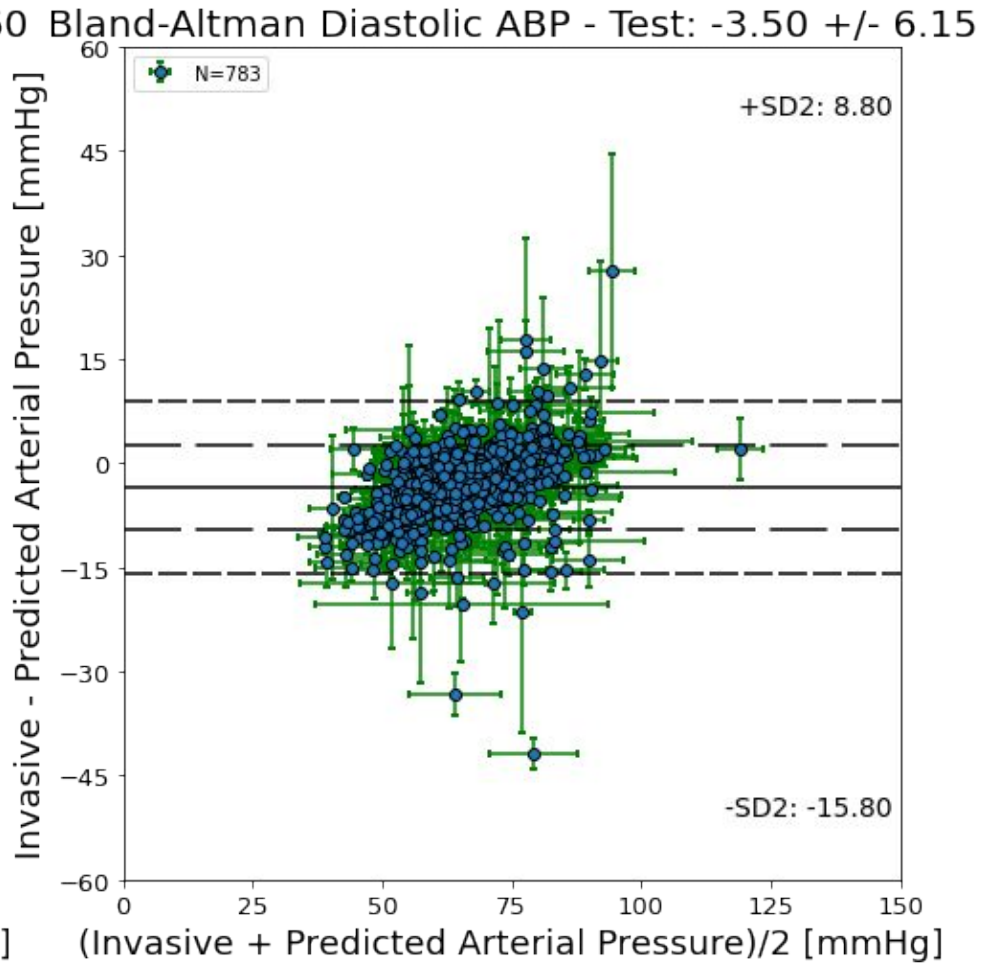
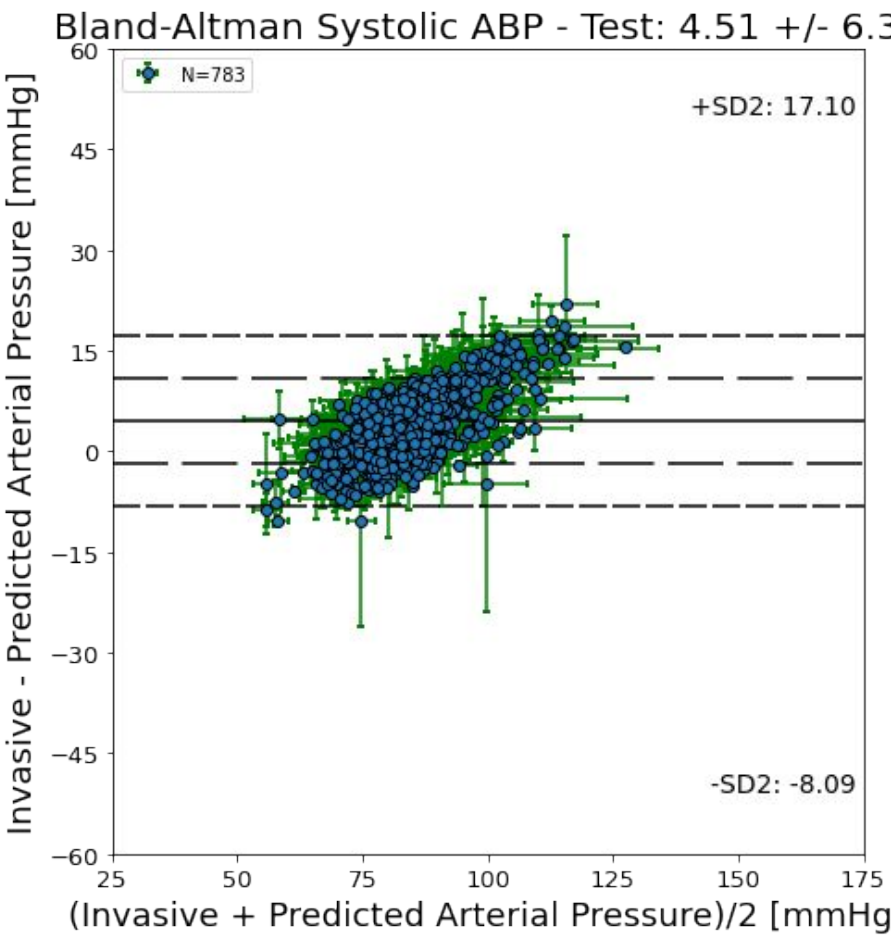
80
70
60
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Time (s)

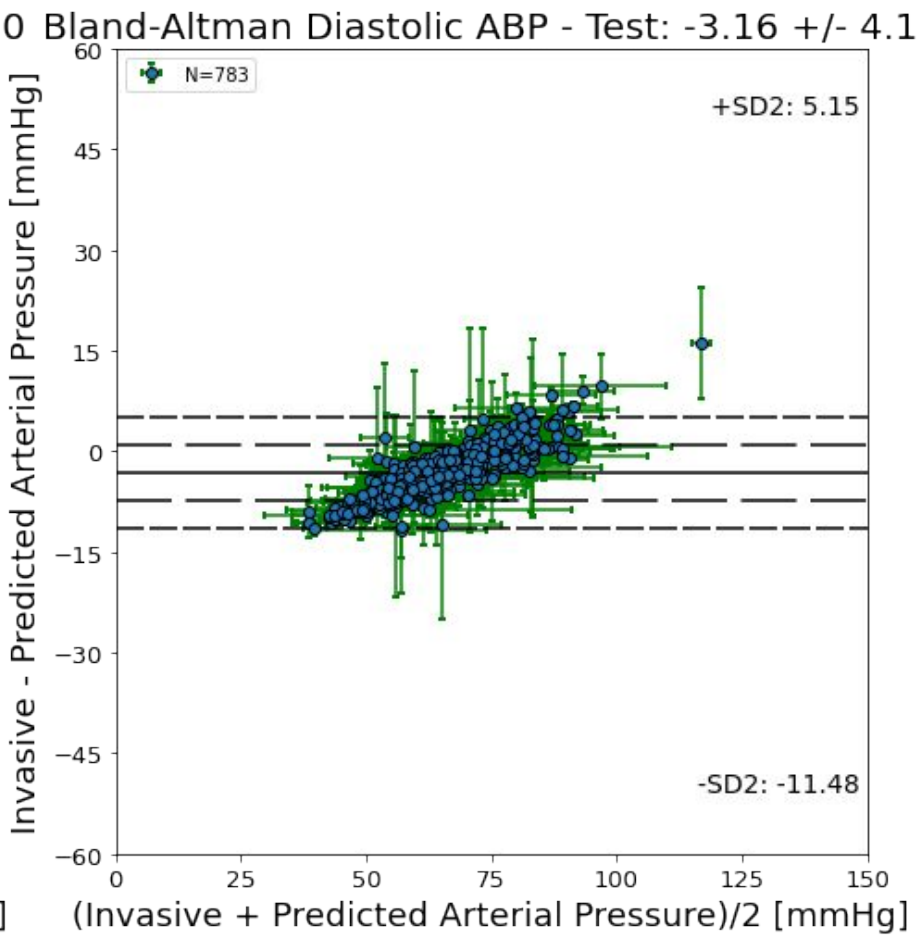
Bland Altamn on 1D Vnet

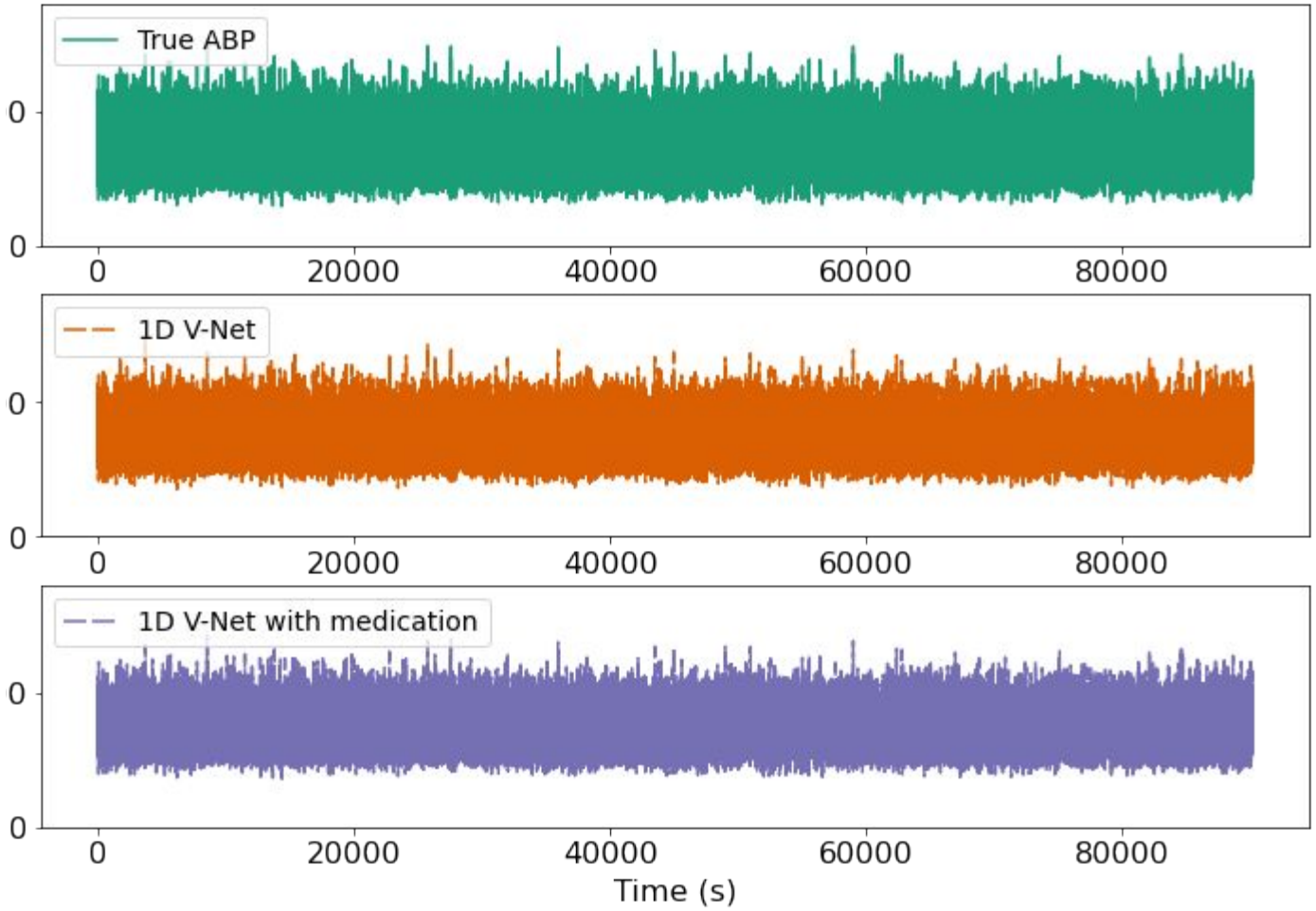


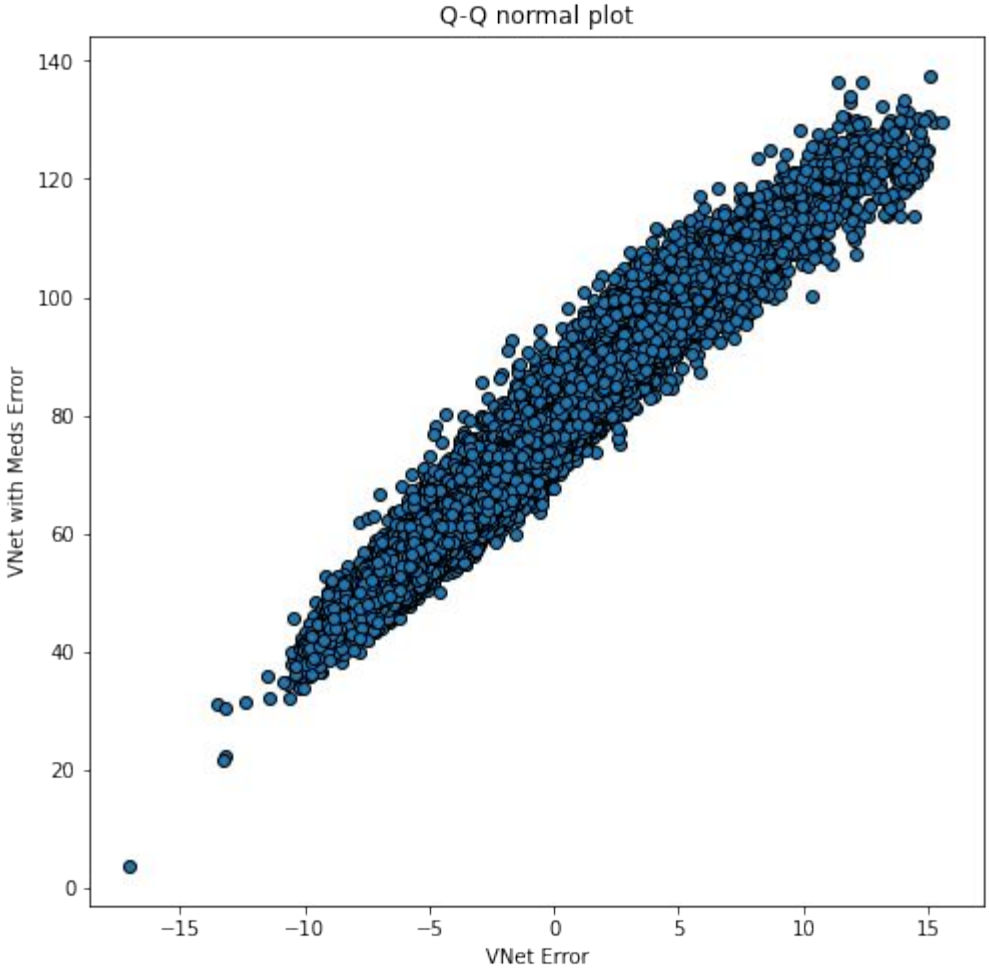


Bland Altamn on 1D Vnet with Medication






True ABP
1D V-Net
1D V-Net with medication
0
0
0
0
0
0
0
20000
40000
60000
80000
Time (s)


Q-Q normal plot
VNet with Meds Error
VNet Error
140
120
100
80
60
40
20
0
−15
−10
−5
0
5
10
15