

Basic idea

Duke Viral Data:

- Physiological data fitting into model
- Differentiation based on model parameters

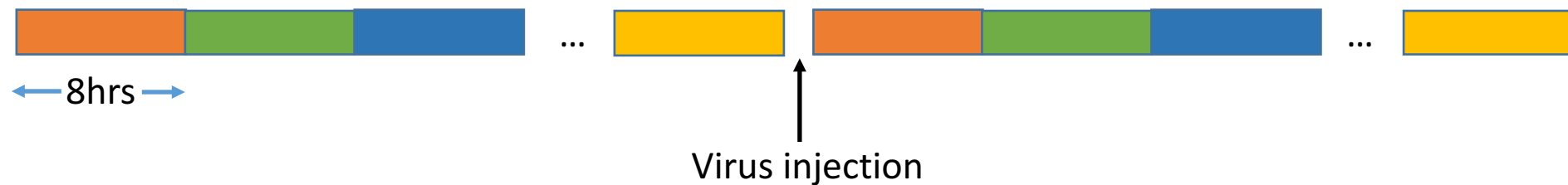
Problem Formulation

- Given the RNA sequencing and physiological data at different time-scales

Phase-I

- Split the physiological data into labelled periods, of length say 8 hr
- Fit the data into fractional growth model

$$D^{\alpha_i} \mathbf{x}(t + 1) = \mathbf{A}_i \mathbf{x}(t) + \mathbf{e}(t)$$



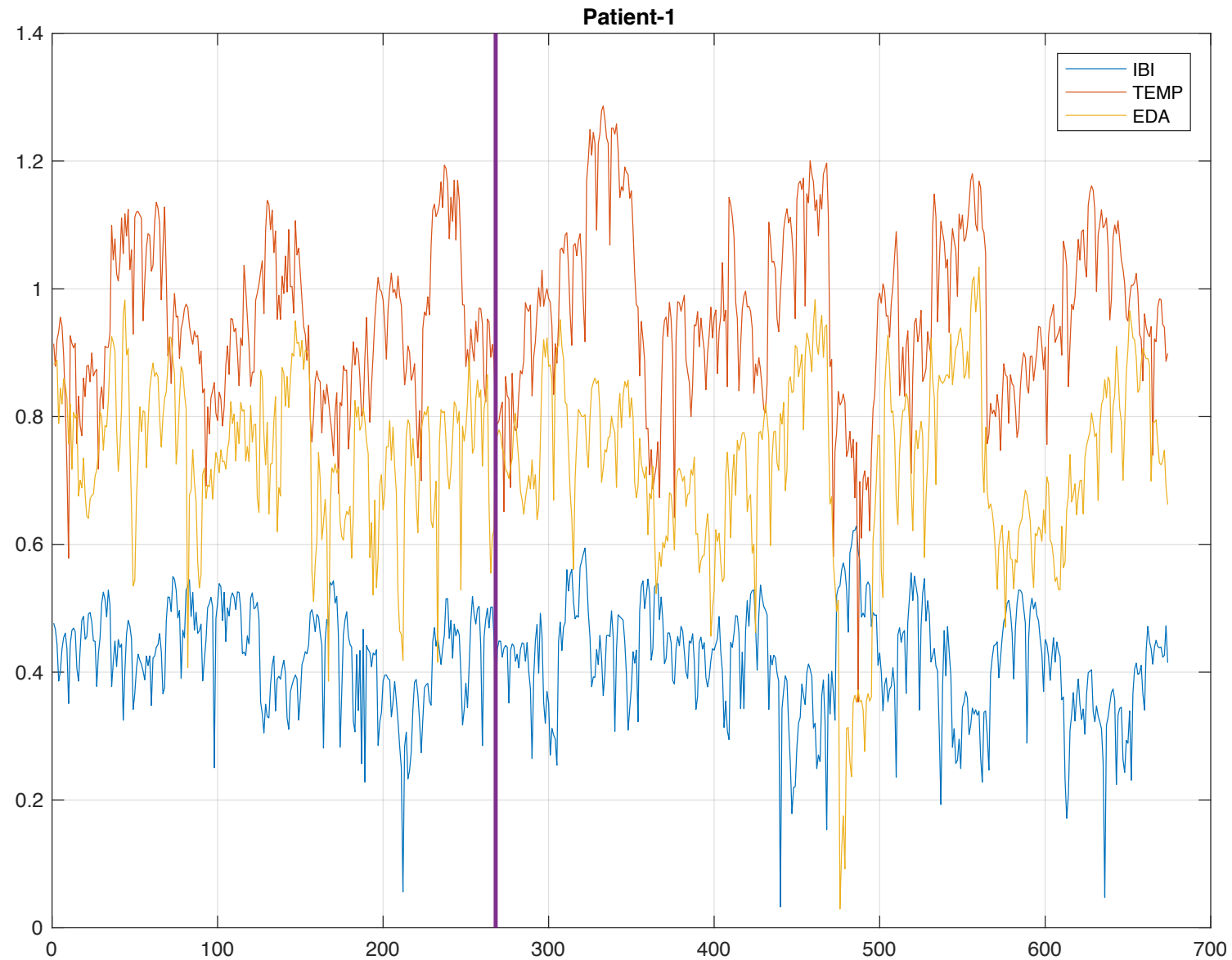
- Observe variations in α_i and A_i and whether we have noticeable change in model parameters after inoculation

Approach and tools

- Probability distribution of α 's before and after injection of virus
- Adjacency matrix parameters
- Information theoretic
 - differentiation of statistics
- Graph theoretic approach
 - differentiate adjacency matrix
- Hypothesis testing based on α and A changes

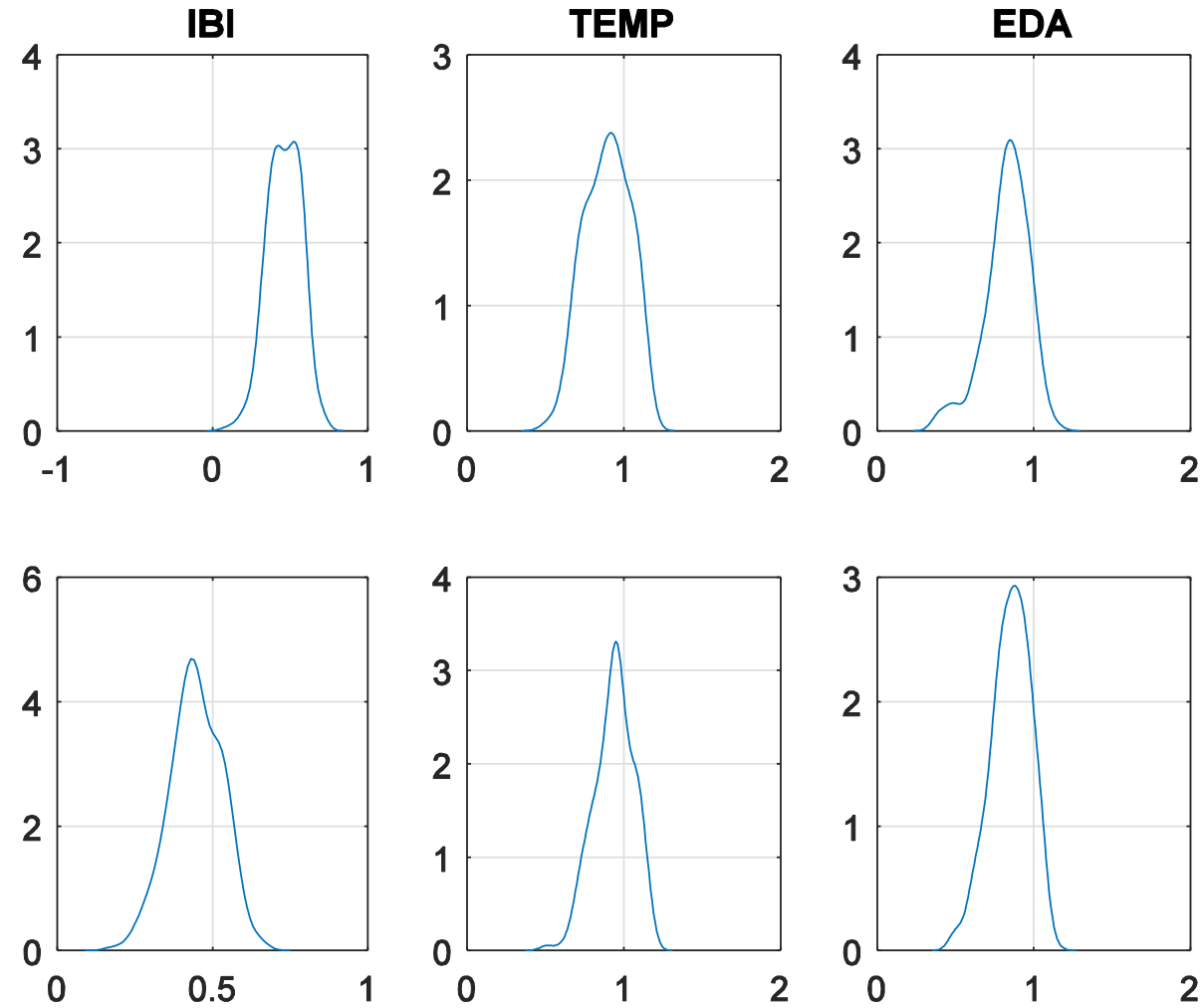
Observation

- For Phase-I



Observation

- For Phase-I



Results

- For Phase-I

	Kulback-Leibler Distance		
Patient ID	IBI	TEMP	EDA
1	0.086263	2.811067	3.506102
2	0.290131	0.089307	0.240607
3	3.797771	0.068311	0.655553
4	6.165668	0.357144	2.030735
5	2.471472	0.862493	0.093966
6	0.144685	0.090454	0.117699
8	2.399644	1.070919	1.030866
9	0.049225	2.636244	0.360741
10	0.100582	0.206398	19.863173
11	0.444050	0.131497	0.138560
14	2.084372	0.306427	0.374999
15	0.015272	0.268811	1.874158
17	0.459410	1.204185	0.314132
18	1.454053	0.060678	3.370449
19	0.374511	0.196298	0.785125
20	2.618138	0.689251	1.004280
21	0.194878	0.159546	0.661406

Results

- For Phase-I
- A hypothesis test:

H_0 : Virus infection present

H_1 : Virus infection absent

- Confidence of hypothesis testing
 - KL-distance thresholding of fractional–order exponent probability distributions
 - Adjacency matrix/coupling matrix of features (to be done)

Observation

- For Phase-I

	Kullback-Leibler Divergence		
Pat-ID	IBI	TEMP	EDA
HRV15-002	0.173279	2.504072	3.137666
HRV15-003	0.023487	0.097416	0.227558
HRV15-004	0.641383	0.077428	0.130656
HRV15-005	7.193331	0.189274	1.170232
HRV15-006	0.062226	0.918632	0.570838
HRV15-007	0.063343	0.066379	0.138420
HRV15-008	0.133647	2.181073	3.091246
HRV15-009	0.746287	0.443175	0.237064
HRV15-011	0.020584	3.429671	1.422036
HRV15-012	0.106071	0.711263	12.581922
HRV15-013	0.084472	0.090211	0.228250
HRV15-017	0.293023	0.019888	0.514707
HRV15-018	9.538796	0.245830	1.584160
HRV15-020	2.394786	1.060199	0.329595
HRV15-021	1.259313	0.043218	3.004294
HRV15-022	0.288635	0.212886	0.136858
HRV15-023	2.295134	1.120438	0.840346
HRV15-024	0.127899	0.397536	3.011950

Observation

- For Phase-I

Pat-ID	KL-Distance			Shedding
	IBI	TEMP	EDA	
HRV15-002	0.173279	2.504072	3.137666	1
HRV15-003	0.023487	0.097416	0.227558	0
HRV15-004	0.641383	0.077428	0.130656	1
HRV15-005	7.193331	0.189274	1.170232	1
HRV15-006	0.062226	0.918632	0.570838	0
HRV15-007	0.063343	0.066379	0.138420	0
HRV15-008	0.133647	2.181073	3.091246	0
HRV15-009	0.746287	0.443175	0.237064	1
HRV15-011	0.020584	3.429671	1.422036	1
HRV15-012	0.106071	0.711263	12.581922	0
HRV15-013	0.084472	0.090211	0.228250	0
HRV15-017	0.293023	0.019888	0.514707	1
HRV15-018	9.538796	0.245830	1.584160	1
HRV15-020	2.394786	1.060199	0.329595	1
HRV15-021	1.259313	0.043218	3.004294	0
HRV15-022	0.288635	0.212886	0.136858	0
HRV15-023	2.295134	1.120438	0.840346	1
HRV15-024	0.127899	0.397536	3.011950	0

Observation

- For Phase-I

Pat ID	KL Distance			Shedding	Symptom
	IBI	TEMP	EDA		
HRV15-002	0.173279	2.504072	3.137666	1	1
HRV15-003	0.023487	0.097416	0.227558	0	1
HRV15-004	0.641383	0.077428	0.130656	1	1
HRV15-005	7.193331	0.189274	1.170232	1	1
HRV15-006	0.062226	0.918632	0.570838	0	0
HRV15-007	0.063343	0.066379	0.138420	1	0
HRV15-008	0.133647	2.181073	3.091246	1	1
HRV15-009	0.746287	0.443175	0.237064	1	1
HRV15-011	0.020584	3.429671	1.422036	1	1
HRV15-012	0.106071	0.711263	12.581922	1	1
HRV15-013	0.084472	0.090211	0.228250	0	1
HRV15-017	0.293023	0.019888	0.514707	1	1
HRV15-018	9.538796	0.245830	1.584160	1	1
HRV15-020	2.394786	1.060199	0.329595	1	1
HRV15-021	1.259313	0.043218	3.004294	1	0
HRV15-022	0.288635	0.212886	0.136858	0	0
HRV15-023	2.295134	1.120438	0.840346	1	1
HRV15-024	0.127899	0.397536	3.011950	1	0

Observation

- For Phase-I

Pat ID	KL Distance				Shedding	Symptom
	IBI	TEMP	EDA	BVP		
HRV15-002	0.173279	2.504072	3.137666	0.581179	1	1
HRV15-003	0.023487	0.097416	0.227558	0.671365	0	1
HRV15-004	0.641383	0.077428	0.130656	1.101871	1	1
HRV15-005	7.193331	0.189274	1.170232	1.958907	1	1
HRV15-006	0.062226	0.918632	0.570838	0.092094	0	0
HRV15-007	0.063343	0.066379	0.138420	1.340476	1	0
HRV15-008	0.133647	2.181073	3.091246	1.313649	1	1
HRV15-009	0.746287	0.443175	0.237064	0.192068	1	1
HRV15-011	0.020584	3.429671	1.422036	3.752674	1	1
HRV15-012	0.106071	0.711263	12.581922	2.324573	1	1
HRV15-013	0.084472	0.090211	0.228250	0.795717	0	1
HRV15-017	0.293023	0.019888	0.514707	0.040206	1	1
HRV15-018	9.538796	0.245830	1.584160	6.534130	1	1
HRV15-020	2.394786	1.060199	0.329595	0.525407	1	1
HRV15-021	1.259313	0.043218	3.004294	1.158888	1	0
HRV15-022	0.288635	0.212886	0.136858	0.555474	0	0
HRV15-023	2.295134	1.120438	0.840346	0.343171	1	1
HRV15-024	0.127899	0.397536	3.011950	0.094207	1	0

New Methods

Graph Analysis

- Challenges:
 - Weighted
 - Undirected
 - Classical spectral theory may not work

Problem Definition:

$$A_1, A_2, \dots, A_n, A_{n+1}, \dots, A_{n+m}$$

- Differentiate group of matrices
 - CAUSAL
- Structure and function may play role in analysis

New Methods

- Causality is important

• Causal analysis of matrices to differentiate	• Directed information analysis
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Observation

Pat ID	KL Distance				in-degree	Shedding	Symptom
	IBI	TEMP	EDA	BVP			
HRV15-002	0.173279	2.504072	3.137666	0.581179	0.506936	1	1
HRV15-003	0.023487	0.097416	0.227558	0.671365	22.651789	0	1
HRV15-004	0.641383	0.077428	0.130656	1.101871	26.827140	1	1
HRV15-005	7.193331	0.189274	1.170232	1.958907	7.418515	1	1
HRV15-006	0.062226	0.918632	0.570838	0.092094	0.795137	0	0
HRV15-007	0.063343	0.066379	0.138420	1.340476	3.727925	1	0
HRV15-008	0.133647	2.181073	3.091246	1.313649	5.412740	1	1
HRV15-009	0.746287	0.443175	0.237064	0.192068	15.265964	1	1
HRV15-011	0.020584	3.429671	1.422036	3.752674	28.194907	1	1
HRV15-012	0.106071	0.711263	12.581922	2.324573	26.573688	1	1
HRV15-013	0.084472	0.090211	0.228250	0.795717	2.712600	0	1
HRV15-017	0.293023	0.019888	0.514707	0.040206	2.103517	1	1
HRV15-018	9.538796	0.245830	1.584160	6.534130	23.777213	1	1
HRV15-020	2.394786	1.060199	0.329595	0.525407	5.324066	1	1
HRV15-021	1.259313	0.043218	3.004294	1.158888	10.661164	1	0
HRV15-022	0.288635	0.212886	0.136858	0.555474	4.359115	0	0
HRV15-023	2.295134	1.120438	0.840346	0.343171	25.755331	1	1
HRV15-024	0.127899	0.397536	3.011950	0.094207	25.779412	1	0

Observation

- For Phase-I

Pat ID	KL Distance			Shedding	Symptom	
	IBI	TEMP	EDA			
HRV15-002	0.173279	2.504072	3.137666	1	1	
HRV15-003	0.023487	0.097416	0.227558	0	1	
HRV15-004	0.641383	0.077428	0.130656	1	1	type-I
HRV15-005	7.193331	0.189274	1.170232	1	1	
HRV15-006	0.062226	0.918632	0.570838	0	0	
HRV15-007	0.063343	0.066379	0.138420	1	0	
HRV15-008	0.133647	2.181073	3.091246	1	1	
HRV15-009	0.746287	0.443175	0.237064	1	1	type-I
HRV15-011	0.020584	3.429671	1.422036	1	1	
HRV15-012	0.106071	0.711263	12.581922	1	1	
HRV15-013	0.084472	0.090211	0.228250	0	1	
HRV15-017	0.293023	0.019888	0.514707	1	1	type-I
HRV15-018	9.538796	0.245830	1.584160	1	1	
HRV15-020	2.394786	1.060199	0.329595	1	1	
HRV15-021	1.259313	0.043218	3.004294	1	0	type-II
HRV15-022	0.288635	0.212886	0.136858	0	0	
HRV15-023	2.295134	1.120438	0.840346	1	1	
HRV15-024	0.127899	0.397536	3.011950	1	0	type-II

$$P_{e0} = \frac{3}{11} = 0.27$$

$$P_{e1} = \frac{2}{7} = 0.28$$

Observation

- For Phase-I

taking

$$P_{e0} = P(H_1|H_0)$$

$$P_{e1} = P(H_0|H_1)$$

$$P_{e0} = \frac{3}{11} = 0.27$$

$$P_{e1} = \frac{0}{7} = 0$$

Pat-ID	KI-Distance				Shedding	Symptom	
	IBI	TEMP	EDA	Total (th=0.5)			
HRV15-002	0.087730	0.136478	0.129733	0.353941	1	1	type-I
HRV15-003	0.023487	0.128915	0.250926	0.403328	0	1	
HRV15-004	0.260390	0.123366	0.083137	0.466893	1	1	type-I
HRV15-005	0.424132	0.060473	0.341009	0.825614	1	1	
HRV15-006	0.062226	0.061138	0.166757	0.290121	0	0	
HRV15-007	0.063343	0.073125	0.095628	0.232095	1	0	
HRV15-008	0.182230	0.201547	0.758263	1.142040	1	1	
HRV15-009	0.153014	0.362911	0.358424	0.874350	1	1	
HRV15-011	0.150791	0.107199	0.266744	0.524734	1	1	
HRV15-012	0.093125	0.215858	1.016783	1.325766	1	1	
HRV15-013	0.140857	0.088395	0.182686	0.411938	0	1	
HRV15-017	0.076857	0.027516	0.121561	0.225933	1	1	type-I
HRV15-018	0.063786	0.223524	0.398227	0.685537	1	1	
HRV15-020	0.165016	0.136055	0.913507	1.214578	1	1	
HRV15-021	0.157304	0.216465	0.058853	0.432622	1	0	
HRV15-022	0.208628	0.036351	0.131827	0.376805	0	0	
HRV15-023	0.272012	0.378684	0.167235	0.817932	1	1	
HRV15-024	0.064471	0.138550	0.127552	0.330573	1	0	