Signal & Data Analysis in Neuroscience
Bar Ilan, Spring 2020 Due: June 4 10:00 AM.

Assignment 07 Information Theory

1) Roughly 10% of Parkinson's disease patients are early onset (i.e. under the age of 50). A late onset parkinsonian patient displays primarily either akinesia (25%) or tremor (75%) symptoms. However, early onset patients display a high percentage (90%) of akinesia associated symptoms.
a) Calculate the entropy of the symptoms.
b) Calculate the conditional entropy of the symptoms given the age of onset.
c) What is the mutual information between the age and symptom?

2) Gruesome Gnomes have the ability to walk either upright ($p_0(s=U) = 0.75$) or upside down ($p_0(s=D)=0.25$). Two neurons (N_1 and N_2) in the Gnome's vestibular system of the fire differently when the Gnome is standing upright (U) or upside down (D).

%	R_{N1}=100 spikes/s	R_{N1}=0 spikes/s
U	80	20
D	30	70

%	R_{N2}=100 spikes/s	R_{N2}=0 spikes/s
U	90	10
D	50	50

a) Calculate the entropy of the state of the Gnome.
b) Which of the neurons provide more information about the state of the Gnome? **Calculate** the information that it provides on the state.

%	R_{N1}=100 R_{N2}=100	R_{N1}=0 R_{N2}=100	R_{N1}=100 R_{N2}=0	R_{N1}=0 R_{N2}=0
U	80	10	0	10
D	30	20	0	50

c) Assuming that the neurons display the joint probability shown in the table above. What is their joint entropy? Compare to the joint entropy in the independent case and explain.

3) The prevalence of Tourette's syndrome (TS) and of obsessive compulsive disorder (OCD) is 0.5% and 1% of the population respectively. The disorders have high co-morbidity rate: 40% of TS patients suffer from OCD.

a) What are the entropies of the appearance of OCD and of TS?

b) What is the conditional entropy of TS given the occurrence of OCD?

c) What is the mutual information between the two disorders?

4. A neuron responds to different stimuli (stimulus A or B) with a burst of 0-3 spikes at times 10ms, 20ms and 30ms after the stimulus, according to the table below:

10ms	0	0	0		0	1		1	1	1
20ms	0	0	1		1	0		0	1	1
30ms	0	1	0		1	0		1	0	1
Stimulus	A	A	A	B	A	A	B	B	B	B
P	0.05	0.2	0.05	0.05	0.05	0.05	0.05	0.2	0.1	0.2

a) Calculate the entropies of (i) the stimulus (1 point) and (ii) the spike count (1 point).

b) Calculate the conditional entropy of the spike count given the spike pattern (1 point).

c) Calculate which spike time (10 or 30 ms) gives the most information about the stimulus (3 points)?

*Solve all questions analytically No Matlab please.