Bonus: answers for the questions

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1) Can you come up with other features derived from the accelerometer measurements that could be useful to identify the sleep changes based on the phone data?

- I think it is worth to consider if the motions are occurring only during the sleep phases changes. Maybe detected motions after a long pause would be associated with sleep changes more than the episodes occurring after a short interval between two motions. So, the time between two motions would be an another features derived from the accelerometers measurements.
- This only a general presumption, but maybe there are some patterns in time domain in the signal derived from accelerometers what would be correlated to the sleep phase changes? Such techniques as neural network would be useful with detecting these patterns (In the literature there are some studies about the patterns in sleep architecture, maybe it would be relate to the accelerometer measurements?).

By the way…

- I haven't known yet if it would be useful in our research, but I when I worked on the model of heart rate variability during sleep I calculated the values of probability of transition between all combination of sleep phases and exercise episodes. The results from my calculations I show on table 1. I also calculated the probability distribution of sleep phase duration.

Table 1*-Probability matrices of transitions between all possible pairs of sleep stages, together with the percent of occurrence of the sleep stages in the complete time series. The upper part of the table presents the probabilities for the first half of the sleep, and the lower - for the second half. As expected, the results for the first and the second half are clearly different, especially for the transitions between the sleep stages: L to D, L to REM, L to W (micro arousal episodes) and L to Exc. We also observe differences in the percent of occurrence of the sleep stages for deep sleep, REM and wake states. The transition probabilities between the pairs of stages REM and D, W and D, D and L, REM and Exc and also the percent of occurrence of L and Exc generally do not change during sleep.*

I half of sleep – matrix of probability						Sleep stage occurrence [%]
Sleep stage	L	D	REM	W	EXC	
L	-	0,478	0,049	0,052	0,422	0,593
D	0,752	-	0,000	0,017	0,221	0,276
REM	0,760	0,000	-	0,119	0,121	0,049
W	0,049	0,000	0,89	-	0,060	0,054
Exc	0,484	0,038	0,301	0,177	-	0,027
II half of sleep – matrix of probability						Sleep stage occurrence [%]
Sleep stage	L	D	REM	W	EXC	
L	-	0,222	0,092	0,113	0,573	0,665
D	0,776	-	0,020	0,041	0,163	0,108
REM	0,691	0,003	-	0,182	0,124	0,076
W	0,087	0,000	0,803	-	0,110	0,121
Exc	0,386	0,000	0,364	0,250	-	0,030

2) What other de-noising techniques would you use to smooth the resulting signals?

I propose an algorithm for detection peaks in the motion vector based on the analyze of the length of the slope of the local extremum. Only those peaks with sufficient length of the slope would be treated as a motion. Admittedly, this is not a de-noising technique, but it would be helpful with find the motion among the noise. I am a co-author of the quite universal and adaptive algorithm for detecting QRS-complexes in the ECG signal, but it could be used also for the other signals. Short description of that algorithm is in that article: http://cinc.org/archives/2014/pdf/0253.pdf.