An Improved Estimation of Unsuitable Segments of Ballistocardiography Records Using Wavelet Transform

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Aims: A major challenge in BCG measurements is their high sensitiveness to motion artifacts, which degrade signal quality. These motion artifacts depend on the position in which BCG is measured and are due to involuntary movements of the subjects, false contacts with the sensor, vibrations in the environment, etc. Several techniques have been developed, especially for BCG measurements during sleep, to automatically discard the corrupted segments and the amount of signal free of artifacts with respect to the whole recording is defined as the coverage factor. Nevertheless, current approaches to obtain it are mainly based on raw signal analysis, which can potentially discard signal segments of acceptable quality having significant fluctuations in amplitude due to factors such as respiratory rate or baseline drifts. To overcome this drawback, a novel technique which combines both the signal and its wavelet transform is proposed, intended to improve the coverage detection process.

Methods: An analysis based on standard deviation windows of BCG signal and its Continuous Wavelet Transform (CWT) is proposed which is compared against a more traditional technique based in raw signal analysis for 18 recordings obtained from the Kansas public database of BCGs measured in a lying position on a bed with a significant number of motion artifacts on them.

Results: The results in the table show the coverage factor using the two methods for the set of 18 recordings obtained from the database, for which an improvement in the coverage factor up to a 10 % has been obtained in some critical records such as "'X1028'".

ID	Age	Height (cm)	Weight (kg)	Gender	# Beats	Coverage (%) (Only BCG)	Coverage (%) (CWT+BCG)	Difference in beats
'X1005'	19	153	48.3	'F'	566	95.05	99.11	23
'X1006'	28	183.6	75.6	'M'	507	98.61	99.40	4
'X1007'	27	197.8	87.1	'M'	453	97.13	97.79	3
'X1010'	47	158.6	67.5	'F'	541	98.89	99.44	3
'X1012'	27	177.8	110	'M'	538	95.91	97.39	8
'X1019'	22	165	67.5	'F'	406	85.71	87.19	6
'X1020'	22	178.8	73.4	'M'	596	97.14	98.99	11
'X1025'	53	167.8	136	'F'	645	93.95	99.68	37
'X1026'	18	147.6	56.4	'F'	594	99.49	100	3
'X1028'	21	172.5	53.6	'F'	469	87.42	97.01	45
'X1035'	20	172	82.1	'F'	532	97.55	99.06	8
'X1039'	59	184.2	80.7	'M'	408	98.28	99.26	4
'X1040'	24	161.1	68.5	'F'	624	97.2	99.03	11
'X1042'	65	170.5	53.7	'F'	527	96.5	98.48	10
'X1043'	60	161.4	102	'F'	409	96.57	99.02	10
'X1044'	31	176.5	70.4	'F'	495	99.19	99.79	3
'X1046'	22	164.6	88.8	'F'	436	92.66	100	32
'X1047'	32	157	57.6	'F'	551	96.37	97.45	6

Conclusion: The proposed technique has proven to be efficient for increasing the coverage factor in the recordings analyzed, which can be especially useful for continuous monitoring applications.