

Nature Scientific Reports

“Contactless radar-based breathing monitoring of premature infants in the neonatal intensive care unit”

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Supplementary File 1: Matlab codes

- readRadarRaw.m: simple function for reading radar .csv files with the raw data in I and Q format.
- testReadRadarRaw.m: procedure for test the reading of radar files and plot.

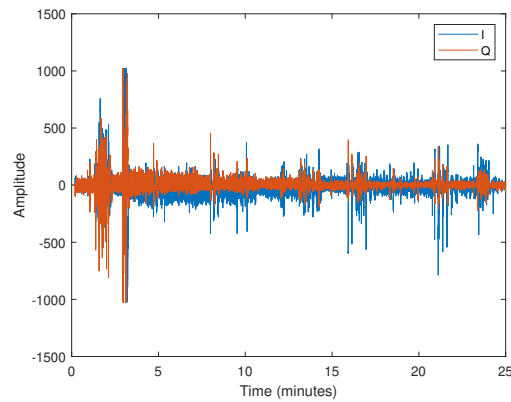


Fig. 1: Radar raw data in I and Q format.

- readReferenceData.m: simple function for reading the reference device .edf files, with the raw data and reference frequency values.
- testReadReferenceData.m: procedure for test the reading of reference files and plot.

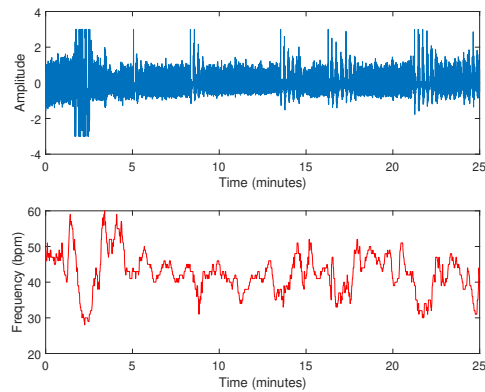


Fig. 2: Reference cabled device raw data (top) and correspondent frequency values (bottom).

Supplementary File 2: Patient's information

- Supplementary Table 1: Summary of patient's information.

patient	01	02	03	04	05	06	07	08	09	10	11	12
sex	m	f	m	m	m	m	m	f	m	f	m	m
gestation age [weeks]	28	28	36	32	28	28	34	34	35	26	27	30
gestation weight [g]	1495	1250	2080	1990	850	760	2430	2210	1490	990	1145	1940
gestation length [cm]	40	38	45	46	36	35	48	48	37	34	38	41
age at measurement [days]	63 ± 1	63 ± 1	10 ± 1	9 ± 2	91 ± 1	91 ± 1	14 ± 1	14 ± 1	18 ± 2	50 ± 2	52 ± 1	28 ± 1
body weight at measurement [g]	2650	2618	2165	2165	2165	2165	2165	2165	2165	2165	2165	2165
body length at measurement [cm]	47	47	46	46	-	-	50	50	45	-	45	50
measurements per patient	3	3	3	3	3	3	3	3	3	3	3	3
time per measurement [min]	25	25	25	25	25	25	25	25	25	25	25	25
diagnosis												
respiratory distress syndrome	x	x	-	-	x	x	x	-	-	x	x	-
apnea bradycardia syndrome	x	x	-	x	x	x	x	x	x	x	x	x
bronchopulmonary dysplasia	-	-	-	-	-	-	-	-	-	x	x	-
respiratory adaptive disorder	-	-	-	-	-	-	-	x	x	-	-	x

- Supplementary Fig. 1: Radar distance in each measurement.

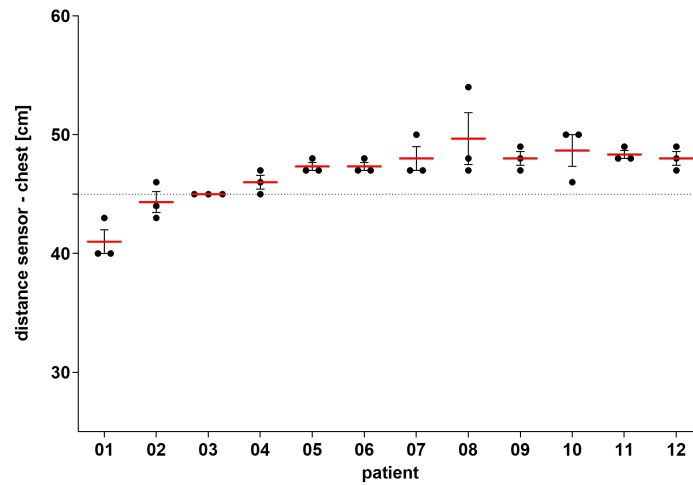


Fig. 1: Radar distance in each measurement.

Supplementary File 3: Patient's protocols

- Supplementary Table 2a: patient's protocols (1-3). ¹

measure- ment	co- bedding	position during measurement			lid	interventions	transients
		prone	supine	side			
1.1	yes		x		half- opened	12:34-13:25: nurse at sibling 17:39-18:33: mother at sibling 21:30-22:01: mother at patient	03:17-09:07: hiccups 24:02-25:00: crying
1.2	yes	x			half- opened	06:26-06:49 nurse at patient	04:05-04:26: unsettled 07:00-08:00: unsettled 11:39-12:00: grunting 14:35-15:13: movement 17:57-18:15: movement
1.3	yes		x		half- opened	18:17-19:00: mother at patient	09:12-10:20: movement / yawn 11:50-12:35: movement 14:50-16:30: movement 22:20-24:42: grunting/movement
2.1	yes		x		half- opened	20:00-20:35: nurse at bed	02:48-03:20 sibling unsettled 06:15-07:40 unsettled 08:28-10:50 movement/grunting 11:39-12:00 sibling movement 14:00-14:45: grunting / movement 15:30-15:35: grunting 17:00-18:00: sibling crying 24:00-25:00: yawn
2.2	yes		x		half- opened	16:25-25:00: nurses present in room	02:20-03:25: movement full body 03:25-05:47: movement hand 06:23-07:50: movement / yawn 09:28: pulls cables 10:07-11:50: movement 13:31-14:29: movement hand 18:12-22:35: movement hand
2.3	yes		x		half- opened	05:06-05:30: mother at patient	03:14-04:00: unsettled 07:00-07:30: movement / yawn 09:00-10:00: unsettled 10:48-13:00: unsettled 14:00-16:30: unsettled 18:17-19:05: unsettled 23:04-23:58: unsettled 24:28-25:00: yawn
3.1	no	x			closed	04:40-05:10: nurse at bed	07:00-08:00: movement 10:10-11:05: movement/yawn 16:54-17:26: unsettled 18:38-19:00: movement hand 19:08-19:30: movement/yawn 21:30-22:07: movement/yawn
3.2	yes	x			closed	-	03:50-04:05: sibling movement 08:30-09:15: movement/yawn 09:40-10:40: sibling movement 11:06-11:28: movement/yawn 12:18-12:58: sibling movement 18:13-18:33: movement 19:46-20:07: movement/grunting 21:48-22:05: movement
3.3	yes			x	closed	-	02:47-03:13: movement hand 04:03-04:29: sibling movement 06:47-07:26: unsettled 09:44-10:47: sibling movement 11:07-11:26: movement/yawn 13:24-16:27: sibling movement 20:07-20:39: sibling movement 21:47-22:23: movement 22:45-25:00: sibling movement

¹The timestamps indicate the moments they happened, starting from the beginning of the measurement (00:00" to 25:00").

• Supplementary Table 2b: patient's protocols (4-6). ¹

measure- ment	co- bedding	position during measurement			lid	interventions	transients
		prone	supine	side			
4.1	no		x		closed		03:00-03:10: movement/yawn 15:10-15:40: unsettled 16:32-16:42: twitch 18:52-19:00: movement 19:43-21:27: movement/grunting 23:28-23:57: movement 24:04-25:00: twitch
4.2	no		x		closed	02:54: nurse walks along the bed 06:52: nurse walks along the bed 07:39-08:13: nurse at the bed 09:31: nurse walks along the bed 13:10: nurse walks along the bed 15:50: nurse walks along the bed 17:28: nurse walks along the bed 20:40: nurse at the bed	03:27-05:03: movement 06:00-06:30: hands movement
4.3	no	x			closed	01:07: nurse walks along the bed 05:13: nurse walks along the bed 06:03: nurse walks along the bed	03:36: grunting 05:35-05:50: yawn / movement 07:34-07:58: movement 09:00-09:30: yawn/movement 09:37-11:43: unsettled 12:21-13:20: movement hand 13:20-14:10: movement 15:20-15:40: movement head 16:25-19:00: movement hand 21:00-24:24: movement
5.1	no		x		closed	20:47-25:00: four nurses present in the room	04:23-06:28: grunting / movement 08:57-11:42: unsettled 13:12-13:36: unsettled 13:55-15:42: movement 19:36-20:25: yawn / movement 24:19-24:29: movement
5.2	no		x		closed	-	00:16-03:54: crying 04:06-04:35: crying 09:26-11:46: movement/crying 15:07-16:26: movement 23:53-24:15: movement
5.3	no	x			closed	-	02:20-04:45: unsettled / grunting 06:58-07:30: grunting / movement 10:20-12:13: unsettled / grunting 14:17-14:50: grunting 15:59-16:20: unsettled / movement 18:33-19:12: grunting/movement 23:35-24:06: grunting/movement
6.1	no		x		closed	12:43-13:22: nurse moves bed 16:58-17:23: nurse at the bed	02:56-04:28: movement/grunting 05:05-05:20: movement 06:31-07:40: grunting / yawn 08:17-10:00: movement 12:25-15:55: movement 18:12-18:58: grunting/movement 21:09-22:25: movement 23:30-24:33: grunting 24:23-25:00 crying
6.2	no	x			closed		05:52-06:35: unsettled 11:13-12:10: grunting / movement 14:10-14:50: grunting / movement 16:42-17:14: grunting 18:59-19:43: unsettled 22:50-23:28: unsettled
6.3	no		x		closed		04:22-05:36: grunting / movement 08:39-08:57: yawn 09:04-09:43: grunting / movement hands 10:32-11:30: movement 11:45-12:16: unsettled 14:11-16:03: grunting / movement 18:11-19:21: movement 21:07-22:23: movement

¹The timestamps indicate the moments they happened, starting from the beginning of the measurement (00:00" to 25:00").

• Supplementary Table 2c: patient's protocols (7-9). ¹

measure- ment	co- bedding	position during measurement			lid	interventions	transients
		prone	supine	side			
7.1	no		x		closed	-	05:10-05:35: unsettled 11:06-12:45: movement 17:04-17:34: unsettled
7.2	yes		x		closed	-	02:07-02:29: unsettled 02:44-03:54: sibling unsettled 08:19-10:01: yawn / movement 11:22-11:47: sibling unsettled 14:18-14:45: sibling unsettled 15:09-15:17: movement 16:27-16:42: unsettled 18:55-19:08: sibling unsettled 19:50-20:18: unsettled
7.3	yes	x			closed	02:50-03:15: fasten O2-Sensor	01:38-02:14: unsettled
8.1	no		x		closed	-	all time hands movement 05:41-06:39: movement 08:19-09:01: yawn / movement 13:02-13:17: yawn / movement 16:00-16:48: yawn / movement 17:38-18:00: movement 19:21-20:21: yawn / movement 22:18-22:35: yawn / movement
8.2	yes		x		closed	-	02:53-03:33: grunting / movement 05:14-06:04: grunting / movement 12:18-13:08: grunting / movement 16:15-17:02: movement 19:15-20:17: unsettled / movement
8.3	yes	x			closed	06:00-06:41: nurse at sibling	02:34-02:53: grunting / movement 06:20-06:47: unsettled 10:34-11:08: grunting
9.1	no		x		closed	-	11:12-11:28: yawn 12:56-13:11: grunting 15:13-15:42: unsettled / movement 19:32-19:56: grunting 20:00-20:12: movement
9.2	no		x		closed	-	01:05-02:38: movement / grunting 04:11-04:18: grunting 04:58-06:49: movement 11:00-11:11: movement 12:04-12:51: movement 15:07-15:37: movement 19:49-20:51: movement 22:13-22:27: grunting 23:40-25:00: movement / grunting
9.3	no		x		closed	-	01:00-01:59: grunting / movement 03:49-03:57: grunting / movement 08:55-09:38: grunting / movement 10:27-10:59: grunting / movement 15:01-16:03: grunting / movement 17:45-18:02: grunting / movement 18:52-19:11: grunting / movement 23:23-24:19: grunting / movement

¹The timestamps indicate the moments they happened, starting from the beginning of the measurement (00:00" to 25:00").

• Supplementary Table 2d: patient's protocols (10-12).¹

measure- ment	co- bedding	position during measurement			lid	interventions	transients
		prone	supine	side			
10.1	no		x		closed	-	01:13-01:37: movement 03:24-04:25: yawn / grunting / movement 06:43-07:37: movement / grunting 10:58-11:28: grunting / movement 15:18-16:27: yawn / movement 18:30-19:27: movement
10.2	no	x			closed	-	05:49-06:37: grunting / movement 09:10-09:23: movement 11:07-11:46: movement 12:45-13:09: movement / grunting 14:33-15:13: grunting 20:04-20:10: yawn / movement 22:58-23:04: yawn
10.3	no	x			closed	-	04:01-05:13: movement 09:28-09:45: movement / grunting 13:18-13:56: grunting / movement 17:17-18:14: grunting / movement 21:07-22:14: grunting / movement
11.1	no		x		closed	-	02:04-03:21: grunting / movement 05:16-05:33: yawn / movement 09:29-10:05: yawn / movement 12:47-14:20: grunting / yawn / movement 18:31-18:46: grunting / movement 18:47-19:29: grunting 20:59-21:33: movement 23:52-24:23: grunting / movement
11.2	no		x		closed		02:24-03:46: yawn / movement 06:28-06:37: grunting 07:11-07:56: movement 09:13-09:41: movement 11:27-11:52: yawn / movement 15:24-16:58: movement / grunting 21:39-22:31: movement / grunting
11.3	no		x		closed	09:48-10:35: nurse walks along the bed	02:30-02:52: movement 05:55-06:12: grunting / movement 20:47-21:05: grunting / movement 23:15-24:31: movement
12.1	no	x			closed	05:00: nurse walks along the bed 06:22: nurse walks along the bed	02:36-03:29: movement / yawn 09:02-09:51: movement / grunting 09:58-19:44: hiccups 11:21-12:10: movement 15:50-16:45: yawn / movement 17:24-17:37: movement 18:35-19:29: movement 20:15-20:43: movement 22:00-22:26: yawn / movement
12.2	no	x			closed	-	01:38-02:26: grunting 07:32-08:02: grunting / movement 09:34-09:40: movement 10:37-11:05: yawn / movement 15:33-16:01: grunting 17:03-17:16: grunting 18:43-18:53: yawn 20:30-20:42: grunting 23:36-25:00: hiccups
12.3	no		x		closed	01:12-01:17: mother walks along the bed 10:47-11:16: nurse at bed	01:21-02:31: movement 04:55-05:02: yawn / movement 07:46-09:02: movement / yawn 09:15-09:24: movement 10:40-11:18: movement 13:08-13:37: movement 15:33-16:04: movement / grunting 16:11-16:53: yawn / movement 16:58-17:24: crying 19:07-20:01: movement

¹The timestamps indicate the moments they happened, starting from the beginning of the measurement (00:00" to 25:00").

Supplementary File 4: Bland-Altman's analysis

Figure 1a shows the Bland-Altman plot considering all measurements for the complete solution. The mean bias was 0.262, with 95% upper and lower limits of agreement (LOAs) of 12.01 bpm and -11.48 bpm, respectively. Figure 1b shows the Bland-Altman plot considering all valid estimates for a single measurement (7.3), in prone position (please refer to the Supplementary File 3). It also compares the performance using standard DFT estimation and the complete proposed solution. The mean bias was -0.296, with LOAs of 7.64 bpm and -8.24 bpm, respectively.

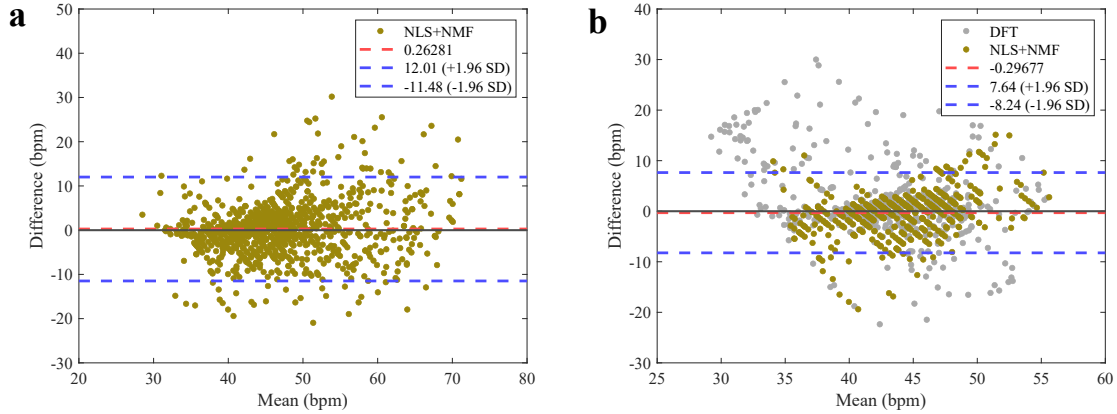


Fig. 1: **Bland-Altman analysis.** **a**, All measurements for the complete solution. **b**, Single measurement, comparing the standard DFT estimation and the proposed solution.