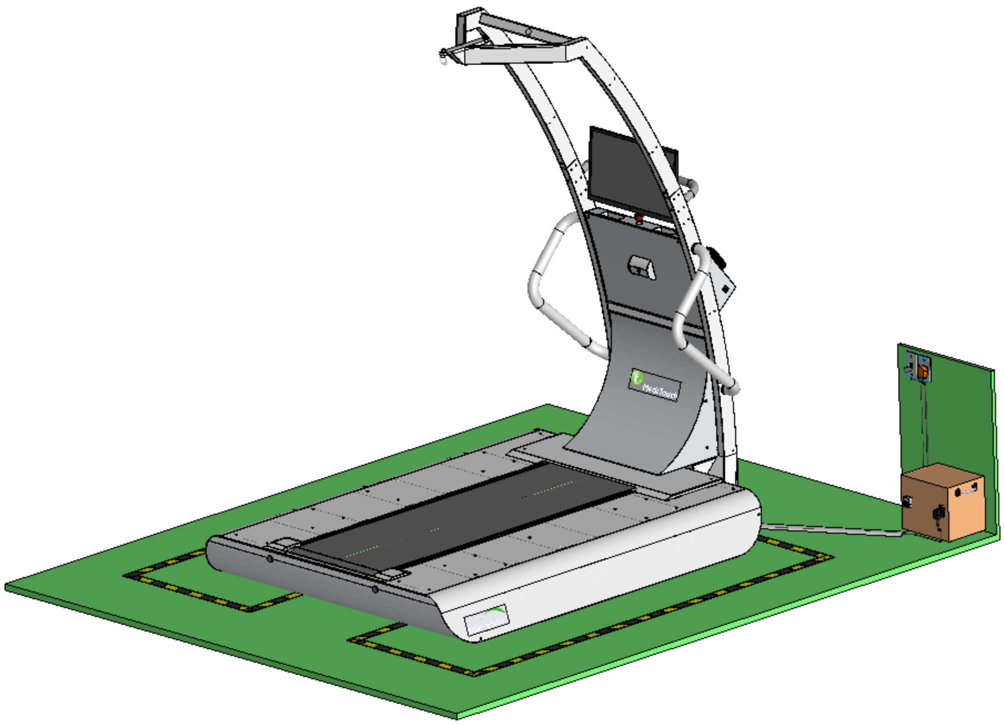
BalanceTutor™

Signal Analysis & Validation Report

Sep 2021



BalanceTutor a dynamic and static postural control trainer

Written by: Ziv Kuniz, MediTouch CTO

Version History

Date	Change description	Written by	Ver.
06 Feb 2018	Initial version.	Ziv K.	180206
28 Feb 2018	Adding section: COP classification algorithm validation	Ziv K.	180226
02 Oct 2018	Adding section: Treadmill Perturbation Kinematics	Ziv K.	181002
26 Dec 2018	Adding: Belt speed validation, Emergency Stop Switch validation, Perturbation Platform Execution Time Validation, Running Belt Start and Stop Time Validation	Ziv K.	181226
14 Jul 2020	Adding: Gait Analysis validation	Ziv K.	200714
16 Nov 2020	Corrections in dynamic perturbation profiles	Ziv K.	201116
01 Sep 2021	Extending Data Acquisition chapter	Ziv K.	210901

E&EO

Table of Contents

1 Introduction

Following document brings few insights about signals generated from the BalanceTutor. This information might use for further signal processing and research purposes.

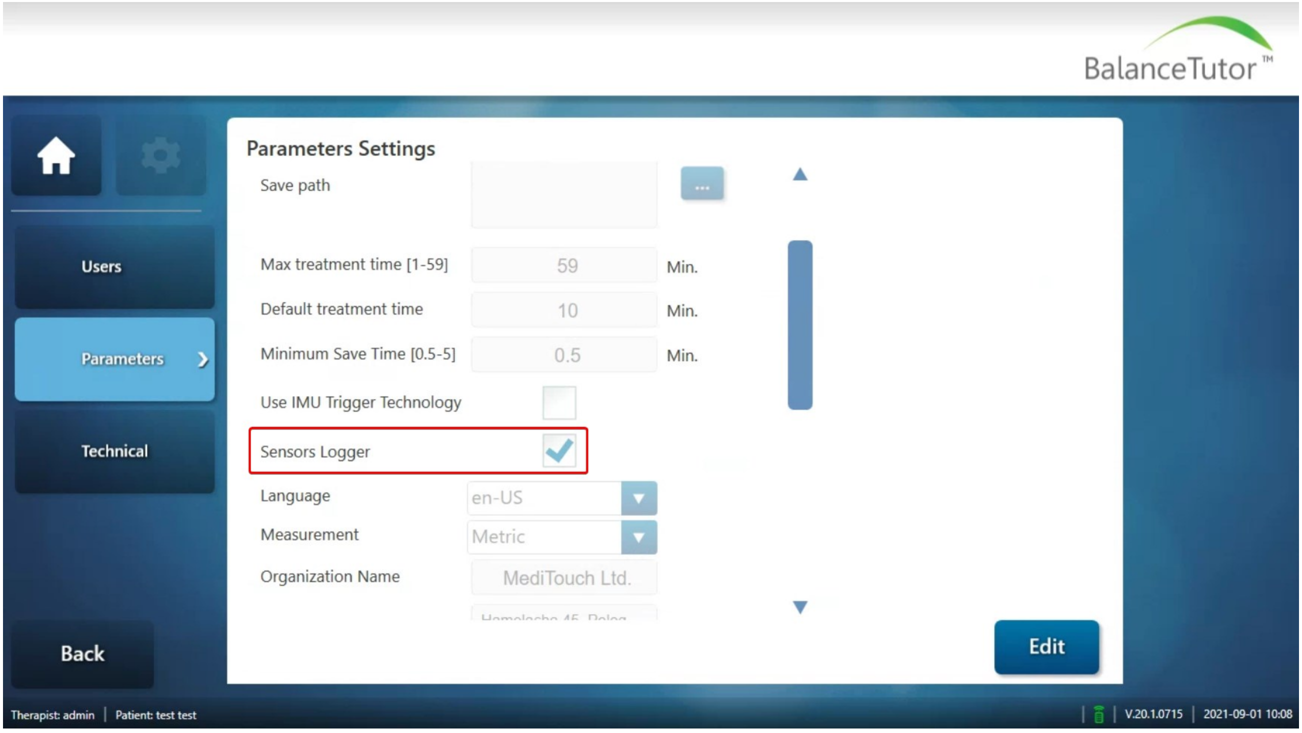
2 Data acquisition

The BalanceTutor software has a data acquisition system that document the kinematic events of the motors and the COP readings of the perturbation platform. The logged data organized in a row and column structure, while each row is a single sample and each column is a sensor or parameter. The logged data is saved in a csv file format at the end of each treatment or evaluation. The amount of information the system writes to the csv file approximated with 60 samples/second.

Engaging with the system data acquisition requires an installed Matlab environment and basic programing skills to be able to access the raw data and perform mathematical investigations.

2.1 Enabling data logging

In order to generate the raw data that the system generates, you need to enable the Sensors Logger checkbox in Settings. Access the application → Settings → Parameters → Enable Sensor Logger.



After this checkbox is enabled, evry end of a treatment a csv file is generated automatically in a local folder of the inner computer.

Note: As a default, the system is configured with this feature as unchecked.

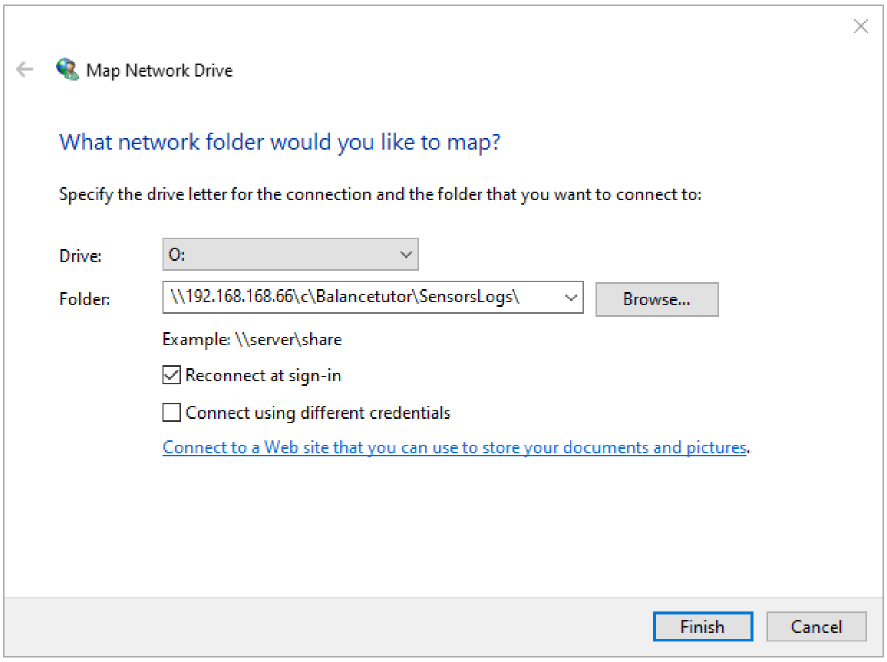
2.2 File access

At the end of each treatment a csv file is generated and placed in the following location: c:\Balancetutor\SensorsLogs\

Note: Do not change any permission/s, add/remove user/s, credentials, group policy rules, user access based domain management (Active Directory), folder locations etc. Such actions prohibited and could cause safety issues that may harm the users and/or the system.

The BalanceTutor is a closed system and accessing the saved files is more challenging. Following are a few options to access the folder and withdraw chosen files:

1. Log Off from BTuser > Enter to BTadmin with the following password: a123456 > navigate to the following folder: c\Balancetutor\SensorsLogs\
   To return the UI (user interface) back to normal, make a simple system restart.
2. From remote computer > build a network folder as follow:



   Note: Open cmd (in command line) and use ipconfig command to check what is the local ip of the BalanceTutor computer in your network.

2.3 CSV file structure

COLUMN	NAME	DESCRIPTION	UNITS
A	ID	Running number	[Count]
B	TIME	System time	[dd-mm-yyyy HH:MM:SS.sss]
C	COP_X	COP X Coordinate	[cm]
D	COP_Y	COP Y Coordinate	[cm]
E	SPEED_TM	Treadmill speed	[cm/s]
F	ImuLeftPacketCount	IMU Left Packet counter	[Count]
G	IMU_LEFT_ACC_X	IMU Left Accelerometer X Axis	[g]
H	IMU_LEFT_Gyro_X	IMU Left Gyroscope X Axis	[deg/s]
I	IMU_LEFT_ACC_Y	IMU Left Accelerometer Y Axis	[g]
J	IMU_LEFT_Gyro_Y	IMU Left Gyroscope Y Axis	[deg/s]
K	IMU_LEFT_ACC_Z	IMU Left Accelerometer Z Axis	[g]
L	IMU_LEFT_Gyro_Z	IMU Left Gyroscope Z Axis	[deg/s]
M	ImuRightPacketCount	IMU Right Packet counter	[Count]
N	IMU_RIGHT_ACC_X	IMU Right Accelerometer X Axis	[g]
O	IMU_ RIGHT _Gyro_X	IMU Right Gyroscope X Axis	[deg/s]
P	IMU_ RIGHT _ACC_Y	IMU Right Accelerometer Y Axis	[g]
Q	IMU_ RIGHT _Gyro_Y	IMU Right Gyroscope Y Axis	[deg/s]
R	IMU_ RIGHT _ACC_Z	IMU Right Accelerometer Z Axis	[g]
S	IMU_ RIGHT _Gyro_Z	IMU Right Gyroscope Z Axis	[deg/s]
T	ImuAPacketCount	IMU A Packet counter	[Count]
U	IMU_A_ACC_X	IMU A Accelerometer X Axis	[g]
V	IMU_A_Gyro_X	IMU A Gyroscope X Axis	[deg/s]
W	IMU_A_ACC_Y	IMU A Accelerometer Y Axis	[g]
X	IMU_A_Gyro_Y	IMU A Gyroscope Y Axis	[deg/s]
Y	IMU_A_ACC_Z	IMU A Accelerometer Z Axis	[g]
Z	IMU_A_Gyro_Z	IMU A Gyroscope Z Axis	[deg/s]
AA	ImuBPacketCount	IMU B Packet counter	[Count]
AB	IMU_B_ACC_X	IMU B Accelerometer X Axis	[g]
AC	IMU_ B _Gyro_X	IMU B Gyroscope X Axis	[deg/s]
AD	IMU_ B _ACC_Y	IMU B Accelerometer Y Axis	[g]
AE	IMU_ B _Gyro_Y	IMU B Gyroscope Y Axis	[deg/s]
AF	IMU_ B _ACC_Z	IMU B Accelerometer Z Axis	[g]
AG	IMU_ B _Gyro_Z	IMU B Gyroscope Z Axis	[deg/s]
AH	ImuCPacketCount	IMU C Packet counter	[Count]
AI	IMU_C_ACC_X	IMU C Accelerometer X Axis	[g]

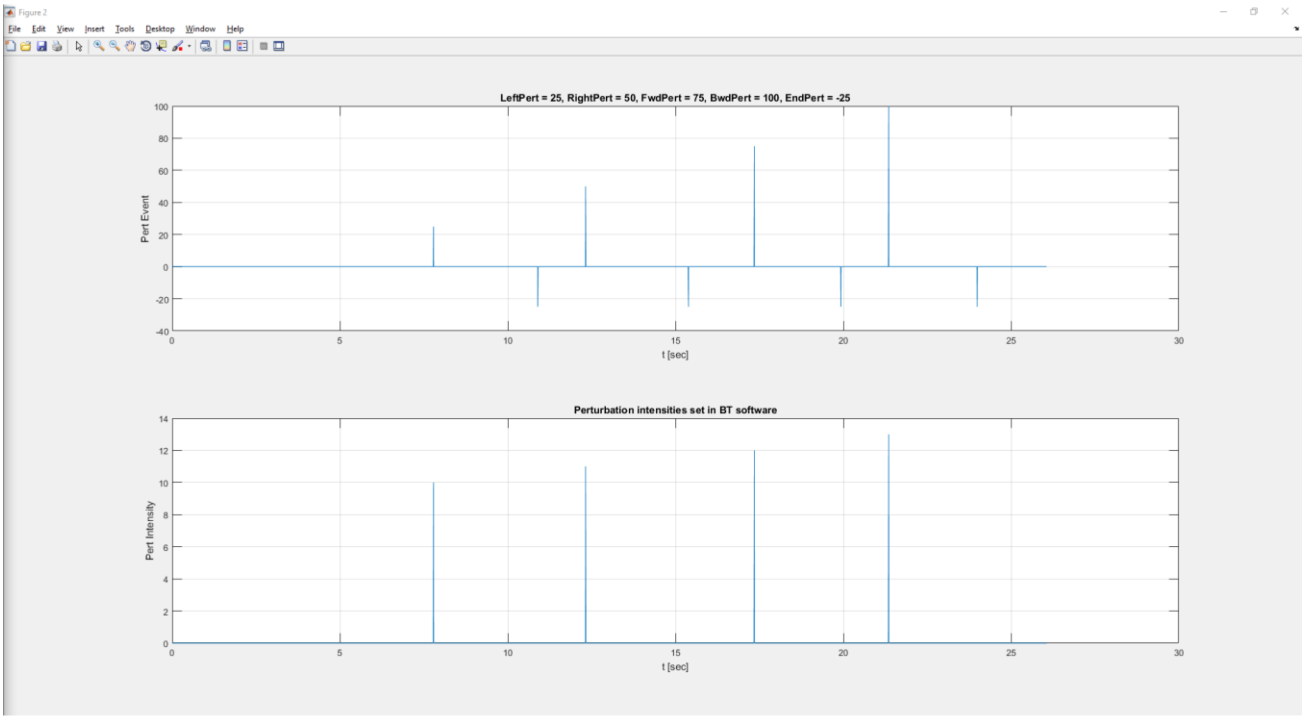
AJ	IMU_ C _Gyro_X	IMU C Gyroscope X Axis	[deg/s]
AK	IMU_ C _ACC_Y	IMU C Accelerometer Y Axis	[g]
AL	IMU_ C _Gyro_Y	IMU C Gyroscope Y Axis	[deg/s]
AM	IMU_ C _ACC_Z	IMU C Accelerometer Z Axis	[g]
AN	IMU_ C _Gyro_Z	IMU C Gyroscope Z Axis	[deg/s]
AO	PERT_TYPE	Perturbation type. One of 5 states: - LeftPert - RightPert - FwdPert - RevPert - Pert End	[String]
AP	PERT_ACC	Perturbation Acceleration	[cm/s^2]
AQ	PERT_DEC	Perturbation Deceleration	[cm/s^2]
AR	PERT_DIST	Perturbation Distance	[cm]
AS	PERT_INTERVAL	INTERNAL USE	
AT	PERT_RTN_ACC	Return from perturbation Acceleration	
AU	PERT_RTN_DEC	Return from perturbation Deceleration	
AV	INTENSITY	Perturbation intensity (1-30)	[ ]
AW	INCREASE_IN_SPEED	Increase in speed from V0 to V1	[m/s]

2.4 Extraction files

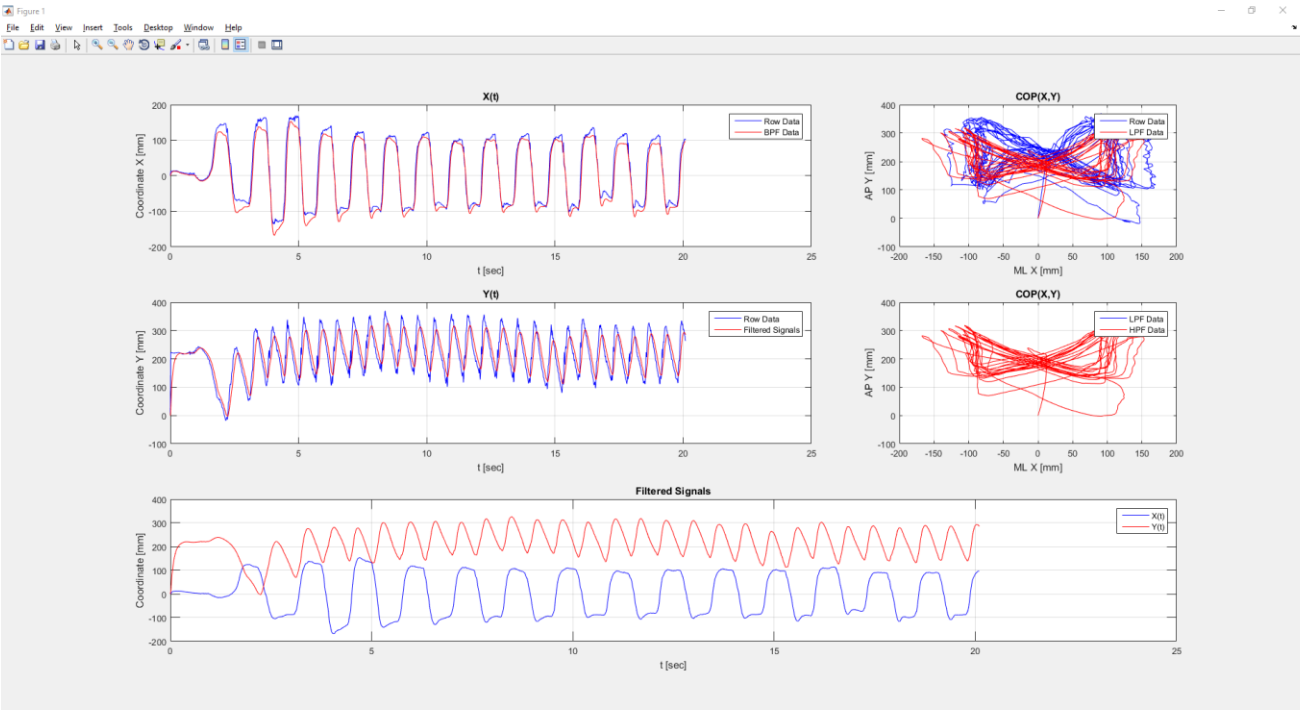
In order to view the information logged to the CSV file, we have developed a Matlab files package. Ask MediTouch for the latest BalanceTutor CSV Extraction File Package.

Following few examples of recorded treatments from the BalanceTutor:

Case 1: Constant walking speed with four perturbation events and four different intensities.



Case 2: COP behavior over time and butterfly constellation over a constant walking speed.



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3 Insights

3.1 COP signal characteristics in a normal walking

Following a record of a 75sec normal walking with 5 lateral perturbations, 3 to the left 2 to the right. Intensity was set to level 8 out of 30 with a walking speed of 2km/h.

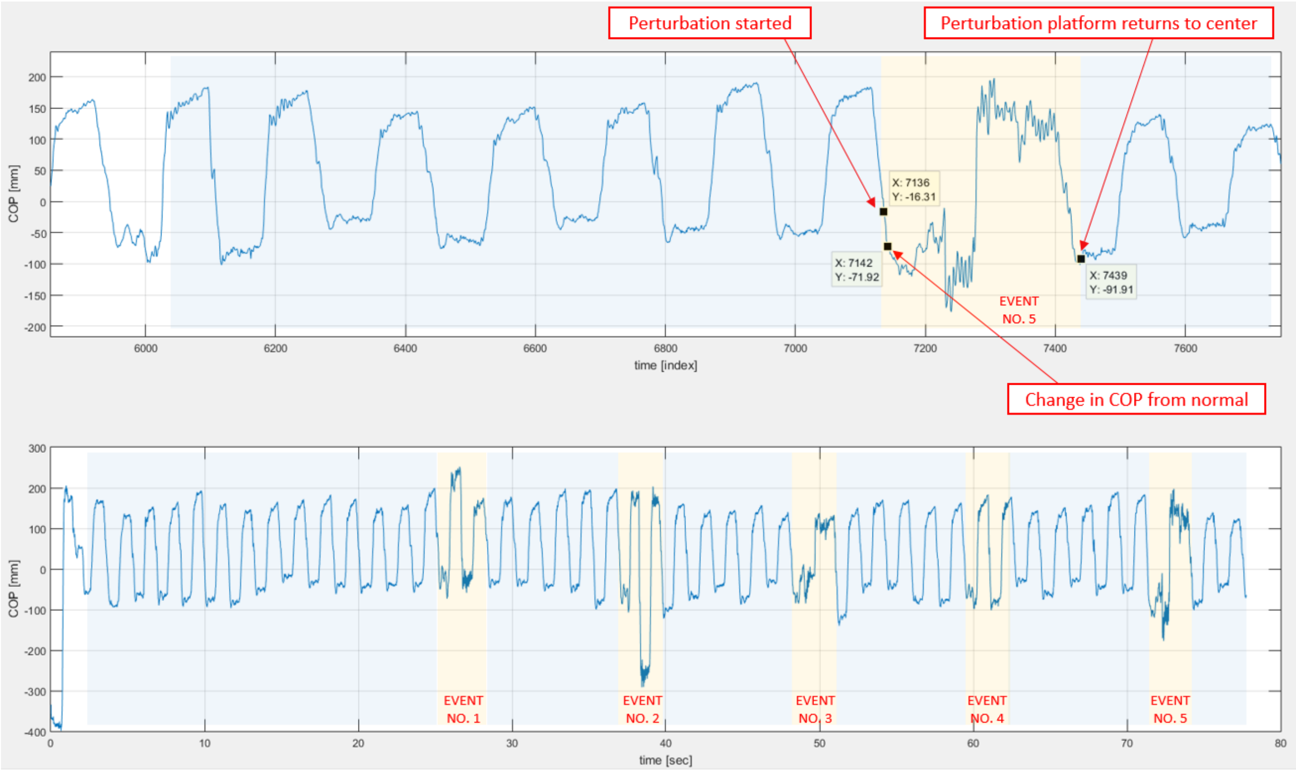
- Resources

Record tracking folder:	REC01
BalanceTutor model:	BT100
BalanceTutor software version:	1.0.11.1107
Subject:	Normal health, age 42, weight 78kg, height 168cm

- Event log

EVENT NO.	PERTURBATION EVENT	TIME ID	Time	COP_X	COP_Y	SPEED_TM*	PERT_TYPE	PERT_ACC	PERT_DEC	PERT_DIST	PERT_INTERVAL	PERT_RTN_ACC	PERT_RTN_DEC
1	Start	2519	06-02-2018 12:04:30.244	1.095	36.527	56	LeftPert	50	52	52	5	203	5
	Stop	2817	06-02-2018 12:04:33.209	15.138	21.984	56	Pert End						
2	Start	3700	06-02-2018 12:04:42.045	0.043	34.769	56	LeftPert	50	52	52	5	203	5
	Stop	4000	06-02-2018 12:04:45.031	-9.976	36.452	56	Pert End						
3	Start	4818	06-02-2018 12:04:53.228	0.028	41.961	56	RightPert	50	52	52	5	203	5
	Stop	5112	06-02-2018 12:04:56.160	-4.325	37.938	56	Pert End						
4	Start	5946	06-02-2018 12:05:04.492	-1.574	45.641	56	LeftPert	50	52	52	5	203	5
	Stop	6246	06-02-2018 12:05:07.480	17.377	25.866	56	Pert End						
5	Start	7134	06-02-2018 12:05:16.357	0.481	36.408	56	RightPert	50	52	52	5	203	5
	Stop	7437	06-02-2018 12:05:19.378	-9.933	44.724	56	Pert End						

- Time based observation



❖ Findings

1. For normal walking with no perturbation events a rather stationary square train signal observed. This signal charectarized with:
   A. Low rate bias variation.
   B. Similare differences between minima and maxima of picks.
   C. Fairly constant dute cycles.
   D. Most of spectral energy will concentrate to low frequencies.
2. During a lateral perturbation event, an abnormal signal behavior observed that charectarized with:
   A. Large rippel at picks of the square train signal.
   B. Different time intervals from perturbation initiation to normal stable walking pattern.
3. Different signal behavior detected in approximattly 40-60msec after perturbation even occured.
4. No clear classification for perturbation pattern type to actual right or left platform direction.

3.2 Perturbation Profile Explanation

Following section will describe in which approach the engine system (treadmill and lateral) varies.

3.3 Static

3.3.1 Forward & Backward Static Perturbation Intensities

Intensity	Pert Distance (x)	a = 2(x/2)/dt^2	v = a*dt
1	1	13	4
2	2	26	7
3	3	38	11
4	4	51	14
5	5	64	18
6	6	77	21
7	7	89	25
8	8	102	29
9	9	115	32
10	10	128	36
11	11	140	39
12	12	153	43
13	13	166	46
14	14	179	50
15	15	191	54
16	16	204	57
17	17	217	61
18	18	230	64
19	19	242	68
20	20	255	71
21	21	268	75
22	22	281	79
23	23	293	82
24	24	306	86
25	25	319	89
26	26	332	93
27	27	344	96
28	28	357	100
29	29	370	104
30	30	383	107

dt	0.28
dx	1

3.3.2 Lateral Static Perturbation Intensities

Intensity	Pert Distance (x)	a = 2(x/2)/dt^2	v = a*dt
1	1.0	13	4
2	1.6	20	6
3	2.2	28	8
4	2.8	35	10
5	3.3	43	12
6	3.9	50	14
7	4.5	58	16
8	5.1	65	18
9	5.7	73	20
10	6.3	80	22
11	6.9	88	25
12	7.4	95	27
13	8.0	102	29
14	8.6	110	31
15	9.2	117	33
16	9.8	125	35
17	10.4	132	37
18	11.0	140	39
19	11.5	147	41
20	12.1	155	43
21	12.7	162	45
22	13.3	170	48
23	13.9	177	50
24	14.5	185	52
25	15.1	192	54
26	15.7	200	56
27	16.2	207	58
28	16.8	215	60
29	17.4	222	62
30	18.0	230	64

dt	0.28
dx	0.586

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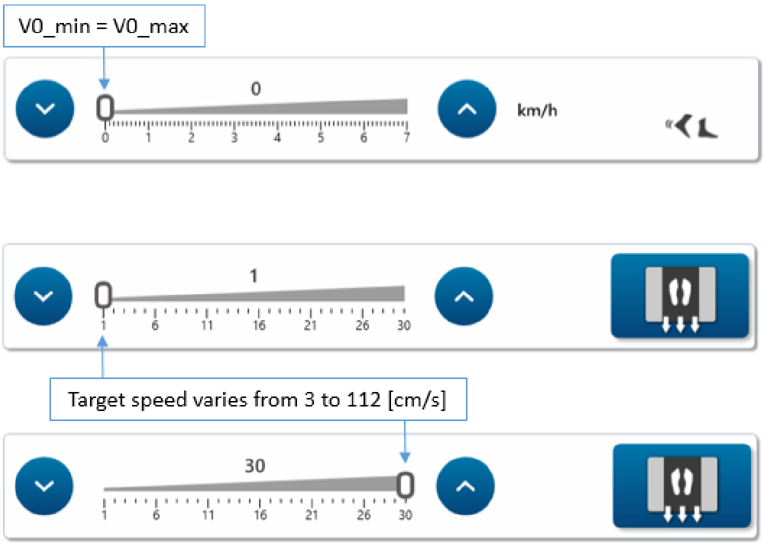
3.4 Dynamic

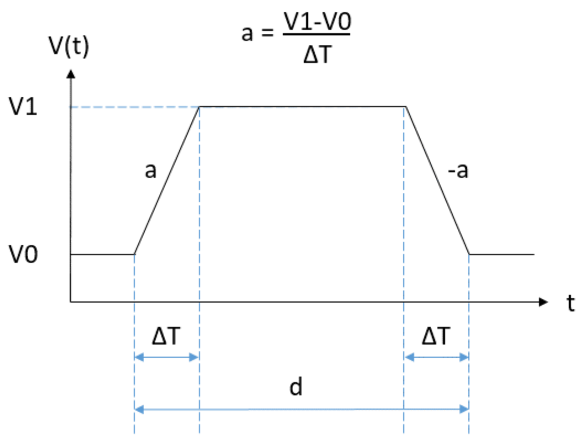
3.4.1 Forward Perturbation Profile

3.4.1.1 Standing State

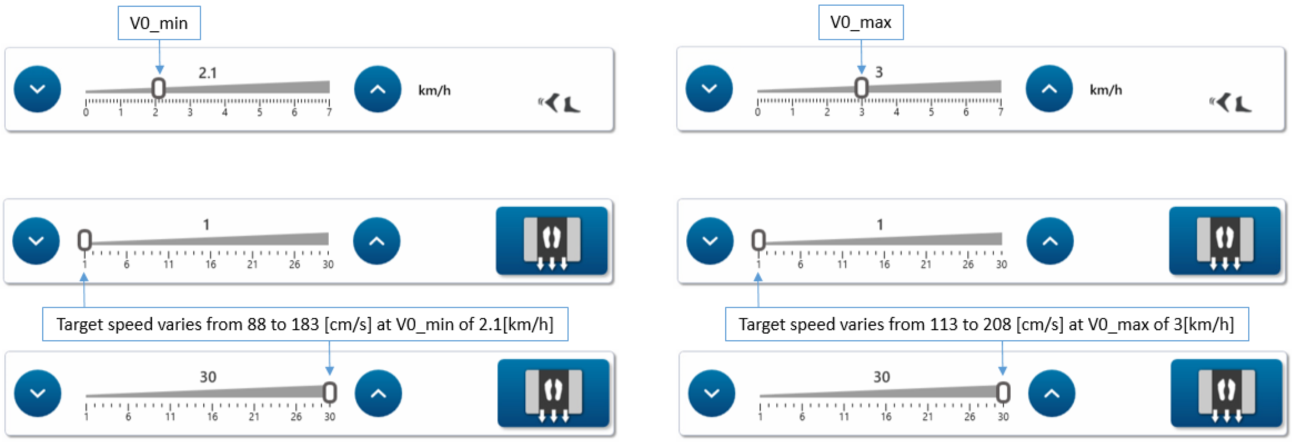
Walking Speed				**Forward Perturbation Model**					
Initial Speed (V0)				Target Speed (V1)				Acceleration Time	Acceleration / Deacceleration	
[km/h]		[cm/s]		[cm/s]		[cm/s]		[s]	[cm/s²]	
V0_min	V0_max	V0_min	V0_max	V1 Range at V0_min		V1 Range at V0_max		ΔT	a_min	a_max
0	0	0	0	3	112	3	112	0.3	10	373



3.4.1.2 Walking State



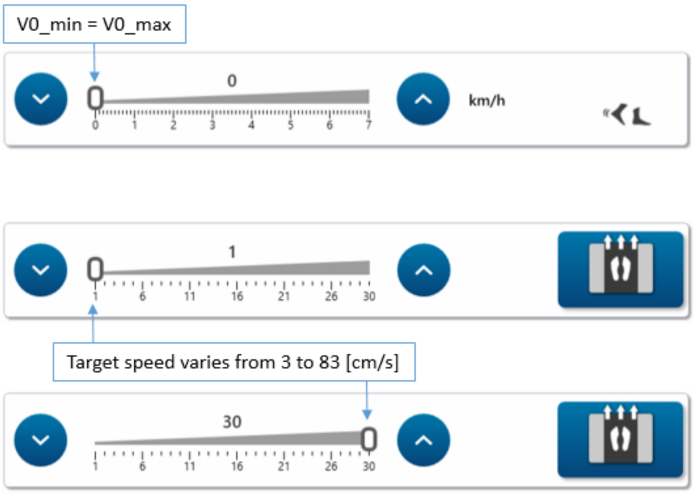
Walking Speed				Forward Perturbation Model						
Initial Speed (V0)				Target Speed (V1)				Acceleration Time	Acceleration / Deacceleration	
[km/h]		[cm/s]		[cm/s]		[cm/s]		[s]	[cm/s²]	
V0_min	V0_max	V0_min	V0_max	V1 Range at V0_min		V1 Range at V0_max		ΔT	a_min	a_max
0.1	1	3	28	6	86	31	111	0.2	15	415
1.1	2	31	56	46	131	71	156	0.2	75	500
2.1	3	58	83	88	183	113	208	0.2	150	625
3.1	4	86	111	131	211	156	236	0.2	225	625
4.1	5	114	139	174	239	199	264	0.2	300	625
5.1	6	142	167	202	239	227	264	0.2	300	485
6.1	7	169	194	209	239	234	264	0.2	200	350



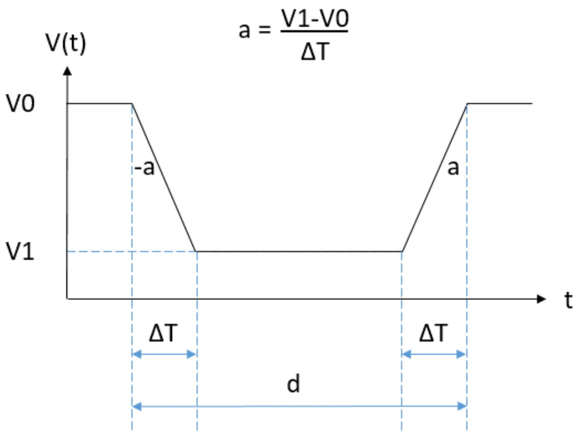
3.4.2 Backward Perturbation Profile

3.4.2.1 Standing State

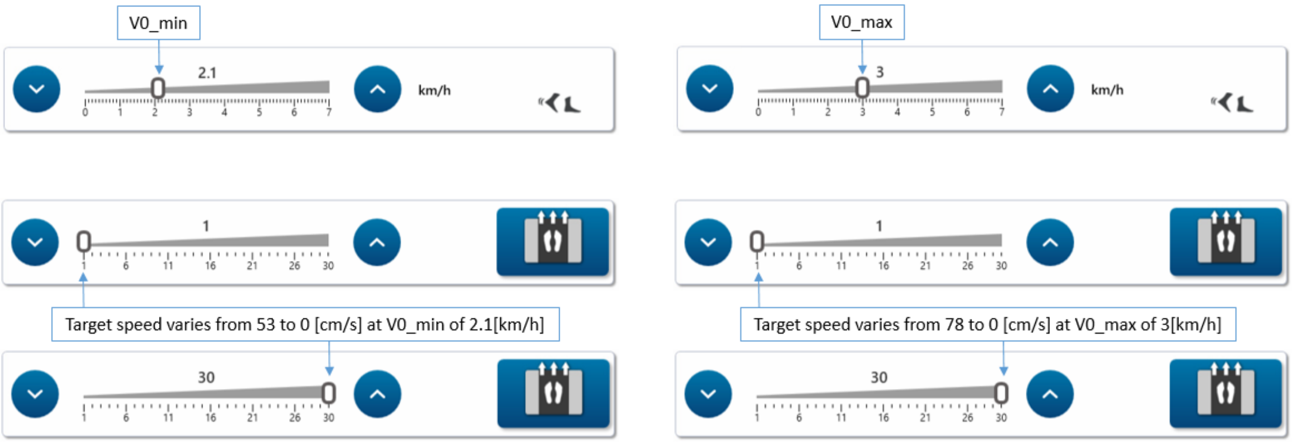
Walking Speed				Backward Perturbation Model					
Initial Speed (V0)				Target Speed (V1)		Acceleration Time		Acceleration / Deacceleration	
[km/h]		[cm/s]		[cm/s]	[cm/s]	[s]		[cm/s²]	
V0_min	V0_max	V0_min	V0_max	V1 Range at V0_min	V1 Range at V0_max	ΔT_min	ΔT_max	a_min	a_max
0	0	0	0	3	83	0.2	0.2	15	373



3.4.2.2 Walking State



Walking Speed				Backward Perturbation Model							
Initial Speed (V0)				Target Speed (V1)				Acceleration Time		Acceleration / Deacceleration	
[km/h]		[cm/s]		[cm/s]		[cm/s]		[s]		[cm/s²]	
V0_min	V0_max	V0_min	V0_max	V1 Range at V0_min		V1 Range at V0_max		ΔT_min	ΔT_max	a_min	a_max
0.1	1	3	28	2	0	27	0	0.2	0.15	5	185
1.1	2	31	56	28	0	53	0	0.2	0.25	15	222
2.1	3	58	83	53	0	78	0	0.2	0.3	29	278
3.1	4	86	111	78	0	103	0	0.2	0.35	43	317
4.1	5	114	139	103	0	128	0	0.2	0.4	57	347
5.1	6	142	167	128	0	153	0	0.2	0.45	71	370
6.1	7	169	194	153	0	178	0	0.2	0.5	85	389



3.4.3 Medial/Lateral Perturbation Profile

This explanation includes both standing and walking states

4 Validation

4.1 COP Classification Algorithm

- Resources

  Record tracking folder: REC03

  BalanceTutor model: BT100

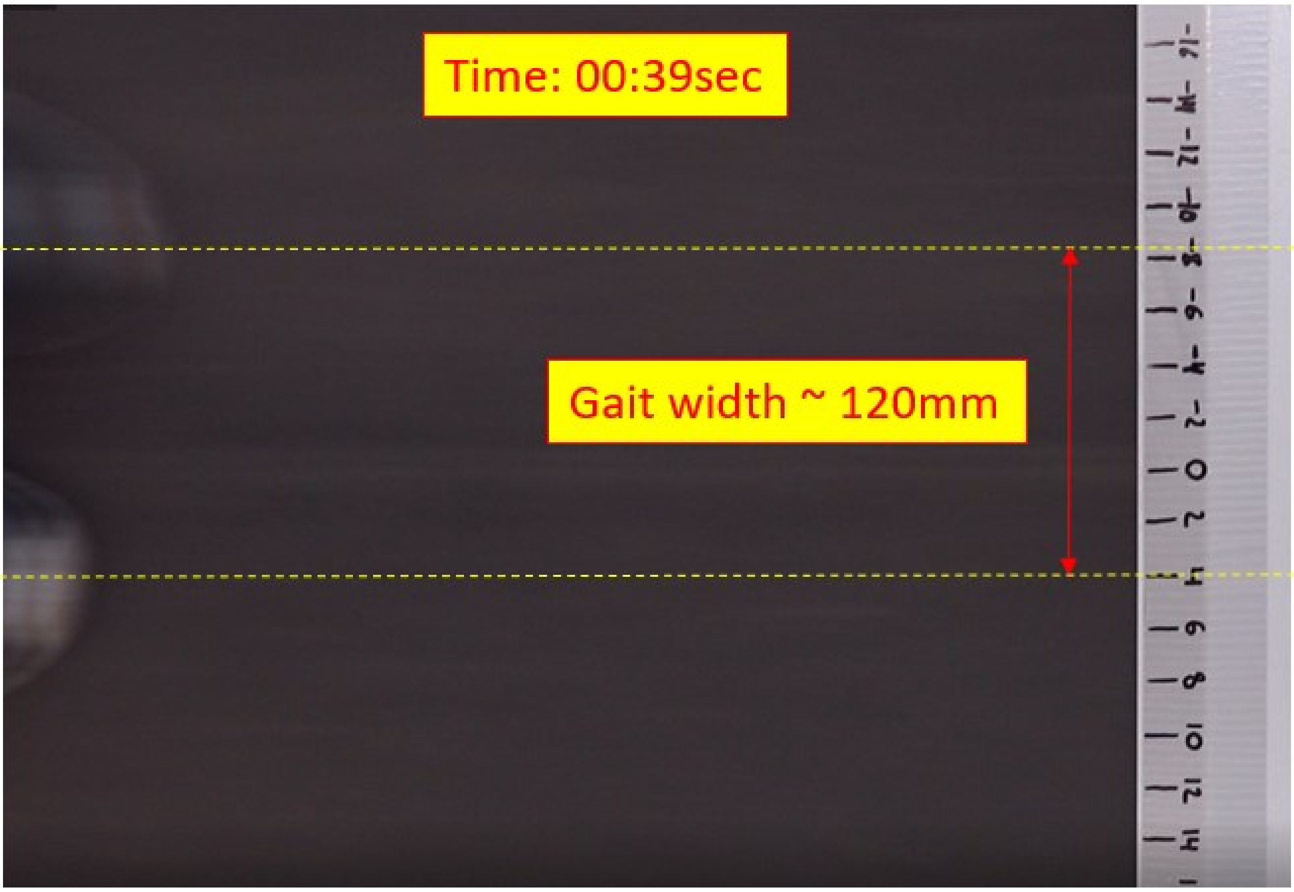
  BalanceTutor software version: 1.0.11.1107

  Subject: Normal health, age 31, weight 74kg, height 185cm

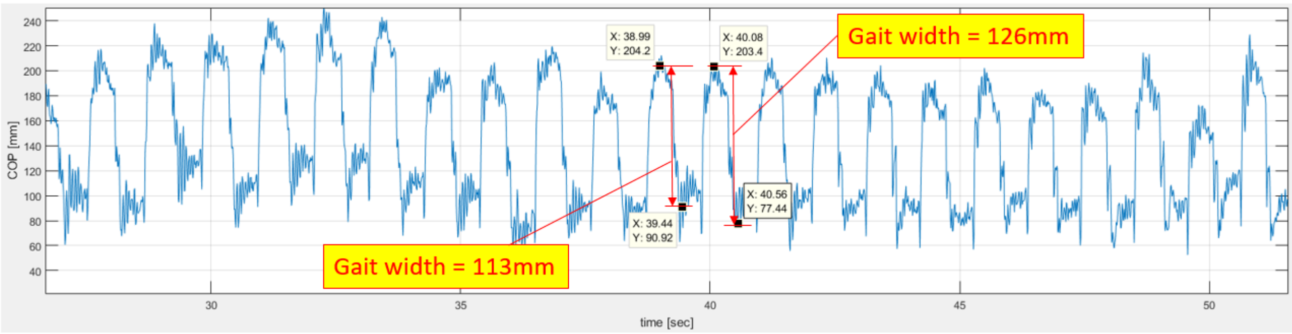
- Protocol

  A. Access to the BT software
  B. Go to Settings then to PArameters
  C. Enable Sensor Logger
  D. Set to Manual Mode
  E. Set Speed to 4.2km/h
  F. Ask the subject to walk normaly
  G. Press PLAY
  H. Record approximattly 1min
  I. After record complited, perform signal analysis using Matlab software

❖ Photo taken to include two feets during normal walking together with ruler taped on the front cover of the BT.



❖ Mtlab analysis for one represantive fragment of the signal.



4.2 Treadmill Perturbation Kinematics

Following measurements recorded using EP204 and EP206 drivers installed in the BalanceTutor.

Reference file: PerturbationSetup_v1.2_160821.xlsx

4.2.1 Treadmill Speed

Following a table shows records detected from the EP206 driver that controls the running belt speed. The smallest speed (non zero) value is **3cm/s** and largest speed value is **194cm/s**.

Index	Running Speed			
	Walking Velocity		Walking Velocity	
	UI Parameter	UI Parameter	StartSpeed (DB)	EndSpeed (DB)
	[km/h]		[cm/s]	
#	V0_min	V0_max	V0_min	V0_max
0	0	0	0	0
1	0.1	1	3	28
2	1.1	2	31	56
3	2.1	3	58	83
4	3.1	4	86	111
5	4.1	5	114	139
6	5.1	6	142	167
7	6.1	7	169	194

4.2.2 Treadmill Perturbation Acceleration & Deacceleration

Following a table shows records detected from the EP206 driver that controls the running belt perturbation acceleration and deacceleration. The smallest acceleration value is **10cm/s²** and largest acceleration value is **625cm/s²**.

Running Speed				Forward Perturbation Model							
Walking Velocity		Walking Velocity		Increase in speed from V0		Perturbation Velocity for min V1		Perturbation Velocity for max V1		Acceleration = DeAcceleration	
UI Parameter	UI Parameter	StartSpeed (DB)	EndSpeed (DB)	Speed (DB)		Calculated Parameter	Calculated Parameter	Calculated Parameter	Calculated Parameter	Acceleration and Deacceleration (DB)	
[km/h]		[cm/s]		[cm/s]		[cm/s]		[cm/s]		[cm/s2]	
V0_min	V0_max	V0_min	V0_max	D_V1_min	D_V1_max	V1_min	V1_max	V1_min	V1_max	a_min	a_max
0	0	0	0	3	112	3	112	3	112	10	373
0.1	1	3	28	3	83	6	86	31	111	15	415
1.1	2	31	56	15	100	46	131	71	156	75	500
2.1	3	58	83	30	125	88	183	113	208	150	625
3.1	4	86	111	45	125	131	211	156	236	225	625
4.1	5	114	139	60	125	174	239	199	264	300	625
5.1	6	142	167	60	97	202	239	227	264	300	485
6.1	7	169	194	40	70	209	239	234	264	200	350

4.2.3 Forward Distance

Following a table shows records detected from the EP206 driver that measures the actual distance under different forward perturbation events. The smallest distance value is **3cm** and largest distance value is **87cm**.

Index	Running Speed				Forward Perturbation Model										
	Walking Velocity		Walking Velocity		Increase in speed from V0		Perturbation Velocity for min V1		Perturbation Velocity for max V1		Acceleration = DeAcceleration		Total Trapezoid		Acceleration Time
	UI Parameter	UI Parameter	StartSpeed (DB)	EndSpeed (DB)	Speed (DB)		Calculated Parameter	Calculated Parameter	Calculated Parameter	Calculated Parameter	Acceleration and Deacceleration (DB)		Distance (DB)		
	[km/h]		[cm/s]		[cm/s]		[cm/s]		[cm/s]		[cm/s2]		[cm]		[s]
#	V0_min	V0_max	V0_min	V0_max	D_V1_min	D_V1_max	V1_min	V1_max	V1_min	V1_max	a_min	a_max	d_min	d_max	DT
0	0	0	0	0	3	112	3	112	3	112	10	373	3	35	0.3
1	0.1	1	3	28	3	83	6	86	31	111	15	415	3	16	0.2
2	1.1	2	31	56	15	100	46	131	71	156	75	500	13	27	0.2
3	2.1	3	58	83	30	125	88	183	113	208	150	625	23	39	0.2
4	3.1	4	86	111	45	125	131	211	156	236	225	625	33	51	0.2
5	4.1	5	114	139	60	125	174	239	199	264	300	625	43	63	0.2
6	5.1	6	142	167	60	97	202	239	227	264	300	485	53	75	0.2
7	6.1	7	169	194	40	70	209	239	234	264	200	350	63	87	0.2

4.2.4 Backward Distance

Following a table shows records detected from the EP206 driver that measures the actual distance under different backward perturbation events. The smallest distance value is **1cm** and largest distance value is **146cm**.

Index	Running Speed				Backward Perturbation Model									
	Walking Velocity		Walking Velocity		Decrease in speed from V0		Perturbation Velocity for min V1		Perturbation Velocity for max V1		Acceleration = DeAcceleration		Total Trapezoid Distance	
	UI Parameter	UI Parameter	StartSpeed (DB)	EndSpeed (DB)	Speed (DB)		Calculated Parameter	Calculated Parameter	Calculated Parameter	Calculated Parameter	Acceleration + Deacceleration (DB)		Distance (DB)	
	[km/h]		[cm/s]		[cm/s]		[cm/s]		[cm/s]		[cm/s2]		[cm]	
#	V0_min	V0_max	V0_min	V0_max	D_V1_min	D_V1_max	V1_min	V1_max	V1_min	V1_max	a_min	a_max	d_min	d_max
0	0	0	0	0	3	83	3		83		15	373	3	35
1	0.1	1	3	28	1	Current Speed	2	0	27	0	5	185	1	6
2	1.1	2	31	56	3	Current Speed	28	0	53	0	15	222	6	21
3	2.1	3	58	83	6	Current Speed	53	0	78	0	29	278	12	38
4	3.1	4	86	111	9	Current Speed	78	0	103	0	43	317	18	58
5	4.1	5	114	139	11	Current Speed	103	0	128	0	57	347	24	83
6	5.1	6	142	167	14	Current Speed	128	0	153	0	71	370	30	113
7	6.1	7	169	194	17	Current Speed	153	0	178	0	85	389	36	146

4.3 Lateral Perturbation Kinematics

4.3.1 Speed

Following a table shows records detected from the EP204 driver that controls the lateral movement speed of the perturbation platform. The smallest speed value is **5cm/s** and largest speed value is **60cm/s**.

Index	Walking Velocity				Target Velocity (V1)	
	[km/h]		[cm/s]		[cm/s]	
#	V0_min	V0_max	V0_min	V0_max	V1_min	V1_max
0	0	0	0	0	5	60
1	0.1	1	3	28	5	30
2	1.1	2	31	56	5	40
3	2.1	3	58	83	5	50
4	3.1	7	86	194	5	60

4.3.2 Acceleration

Following a table shows records detected from the EP204 driver that controls the perturbation platform acceleration. The smallest acceleration value is **25cm/s²** and largest acceleration value is **200cm/s²**.

Index	Walking Velocity				Target Velocity (V1)		Acceleration to target V1	
	[km/h]		[cm/s]		[cm/s]		[cm/s2]	
#	V0_min	V0_max	V0_min	V0_max	V1_min	V1_max	Acc_min	Acc_max
0	0	0	0	0	5	60	25	200
1	0.1	1	3	28	5	30	25	75
2	1.1	2	31	56	5	40	25	114
3	2.1	3	58	83	5	50	25	156
4	3.1	7	86	194	5	60	25	200

4.3.3 Deacceleration

Following a table shows records detected from the EP204 driver that controls the perturbation platform deacceleration. The smallest deacceleration value is **25cm/s²** and largest deacceleration value is **200cm/s²**.

Index	Walking Velocity				Target Velocity (V1)		DeAcceleration to end distance (speed=0)	
	[km/h]		[cm/s]		[cm/s]		[cm/s2]	
#	V0_min	V0_max	V0_min	V0_max	V1_min	V1_max		
0	0	0	0	0	5	60	25	200
1	0.1	1	3	28	5	30	25	75
2	1.1	2	31	56	5	40	25	114
3	2.1	3	58	83	5	50	25	156
4	3.1	7	86	194	5	60	25	200

4.3.4 Distance

Following a table shows records detected from the EP204 driver that measures the actual distance under different lateral perturbation events. The smallest distance value is **1cm** and largest distance value is **18cm**.

Index	Walking Velocity				Target Velocity (V1)		Lateral Perturbation Distance	
	[km/h]		[cm/s]		[cm/s]		[cm]	
#	V0_min	V0_max	V0_min	V0_max	V1_min	V1_max	D_min	D_max
0	0	0	0	0	5	60	1	18
1	0.1	1	3	28	5	30	1	12
2	1.1	2	31	56	5	40	1	14
3	2.1	3	58	83	5	50	1	16
4	3.1	7	86	194	5	60	1	18

4.4 Emergency Stop Switch

- Purpose: The following test conducted in order to examine the reliability and execution time of the Emergency Stop Switch.

- Test Procedure
  1. Since the load capacity of the BT is 135 kg at the maximum, the subject wears additional cloths so the total weight becomes 140 kg as the worst case. Therefore, we use a subject that simulates a 140Kg load on the BT. Test conducted with two units to confirm that it is not characteristic of the device. The test conducted three times for each device in order to confirm the accidental result at the time of the measurement.

  2. Sequence:
     A. Set the BT software to a manual mode
     B. Set speed to 7 km/h
     C. Set treatment duration to 5min
     D. Press PLAY
     E. Prepare and reset the Stop Watch
     F. Press Emergency Stop Switch and on the same time initiate the Stop Watch counter
     G. When running belt completely stopped, stop the Stop Watch counting.
     H. Write the execution time from the Stop Watch
     I. Repeat 3 times for all four perturbation directions

  3. Repeat above sequence with another BT

- Results for the BT100 S/N: A183000007

Record #	**Stop Time [sec]**	**Criteria $0.5 \leq t$ [sec] ≤ 0.75**
1	0.58	Pass
2	0.61	Pass
3	0.60	Pass

❖ Results for the BT100 S/N: A183000032

Record #	**Stop Time [sec]**	**Criteria $0.5 \leq t\ [sec] \leq 0.75$**
1	0.62	Pass
2	0.59	Pass
3	0.61	Pass

❖ Conclusion:

This test showed that the system acts as expected in the criteria safety range that where defined in design and no farther precaution actions needed.

4.5 Safety Stop Switch Limits

- Purpose: The following test conducted in order to examine the reliability of the internal Safety Stop Switch. Its purpose to prevent the perturbation platform (moves right and left) to travel above its physical travel distance of ±24cm. If the perturbation platform exceeds the safety limit of ±21.75cm there is a risk of high impact of the moving perturbation platform with the base frame, which is stationary all time.

- Test procedure:
  - A. Turn ON the system
  - B. Complete its designed Homing procedure
  - C. Go to Settings > Device > press one time on +21.75 and one time on -21.75
  - D. Check if for one of the cases the Safety Stop Switch was enabled
  - E. Do the following 1-4 steps 30 times and check stability of action, otherwise report as fault.

- Conclusion: after 30 times of the above procedure, the system acts safely as expected and no farther precaution actions where needed.

4.6 Perturbation Platform Execution Time Validation

- Purpose: Validate the maximal perturbation execution time for all four directions.
- Equipment: Brand ACCUSPLIT, Model 601X, S/N 44587215
- Test Procedure:

1. Use a Stop Watch measurement equipment:

2. Since the load capacity of the BT is 135 kg at the maximum, the subject wears additional cloths so the total weight becomes 140 kg as the worst case. Therefore, we use a subject that simulates a 140Kg load on the BT. Test conducted with two units to confirm that it is not characteristic of the device. The test conducted three times for each device in order to confirm the accidental result at the time of the measurement.

3. Sequence:
   A. Set the BT software to a manual mode
   B. Set speed to 0 km/h
   C. Set Perturbation to maximal (30)
   D. Set treatment duration to 5min
   E. Press PLAY
   F. Prepare and reset the Stop Watch
   G. Initiate perturbation and on the same time start the Stop Watch
   H. When perturbation finished stop the Stop Watch counting
   I. Write the execution time from the Stop Watch
   J. Repeat 3 times for all four perturbation directions

4. Repeat above sequence with another BT

❖ Results for the BT100 S/N: A183000007

Record #	Forward [sec]	Backward [sec]	Right [sec]	Left [sec]	Criteria FW, BW: 0.5 ≤ t [sec] ≤ 1.0 R, L: 0.5 ≤ t [sec] ≤ 1.0
1	0.68	0.70	0.87	0.86	Pass
2	0.71	0.71	0.85	0.87	Pass
3	0.69	0.69	0.88	0.85	Pass

❖ Results for the BT100 S/N: A183000032

Record #	Forward [sec]	Backward [sec]	Right [sec]	Left [sec]	Criteria FW, BW: 0.5 ≤ t [sec] ≤ 1.0 R, L: 0.5 ≤ t [sec] ≤ 1.0
1	0.65	0.67	0.88	0.85	Pass
2	0.71	0.7	0.84	0.89	Pass
3	0.69	0.68	0.86	0.84	Pass

❖ Conclusion:

For both systems, approximately same values measured using the Stop Watch and the motor driver that reported to the computer (then to the user interface) as expected. The load of the subject on the running board did not influenced on target speed set by the user.

4.7 Belt Speed Validation

- Purpose: validate belt speed at ±7kmh with maximal load
- Equipment: Brand UNI-T, Model UT372, S/N C161065532
- Procedure:

1. Set up the measurement equipment accordingly:

2. Consider the following parameter in the calculations: the length of the running belt is 3.32m

   Speed [km/h] = Speed Meter Count [count] * Cyclic Belt Length [m/count] / Duration [h]

3. Since the load capacity of the BT is 135 kg at the maximum, the subject wears additional cloths so the total weight becomes 140 kg as the worst case. Therefore, we use a subject that simulates a 140Kg load on the BT. Test conducted with two units to confirm that it is not characteristic of the device. The test conducted three times for each device in order to confirm the accidental result at the time of the measurement.

4. Sequence:
   A. Set the BT software to a manual mode
   B. Set speed to 7 km/h
   C. Set treatment duration to 5min
   D. Press PLAY button
   E. When record end's, write the time from the speed meter
   F. Repeat 3 times for forward then backward belt direction

5. Repeat above sequence with another BT

- Results for the BT100 S/N: A183000007

Belt direction: Forward

	Speed Meter External Measurement			Driver Measurement	
Record #	**Speed Meter [Count]**	**Measured Distance [m]**	**Measured Speed [km/h]**	**Calculated Distance [m]**	**Target Speed [km/h]**
1	176	584	7.01	581	7
2	176	584	7.01	581	7
3	175	581	6.97	580	7

- Belt direction: Backward

	Speed Meter External Measurement			Driver Measurement	
Record #	**Speed Meter [Count]**	**Measured Distance [m]**	**Measured Speed [km/h]**	**Calculated Distance [m]**	**Target Speed [km/h]**
1	175	581	6.97	580	7
2	176	584	7.01	581	7
3	176	584	7.01	581	7

- Results for the BT100 S/N: A183000032

Belt direction: Forward

	Speed Meter External Measurement			Driver Measurement	
Record #	**Speed Meter [Count]**	**Measured Distance [m]**	**Measured Speed [km/h]**	**Calculated Distance [m]**	**Target Speed [km/h]**
1	176	584	7.01	582	7
2	176	584	7.01	582	7
3	177	587	7.05	585	7

Belt direction: Backward

	Speed Meter External Measurement			Driver Measurement	
Record #	**Speed Meter [Count]**	**Measured Distance [m]**	**Measured Speed [km/h]**	**Calculated Distance [m]**	**Target Speed [km/h]**
1	176	584	7.01	581	7
2	176	584	7.01	580	7
3	176	584	7.01	581	7

- Conclusion:

  For both systems, approximately same values measured using the speed meter and the motor driver that reported to the computer (then to the user interface) as expected. The load of the subject on the running board did not influenced on target speed set by the user.

4.8 Running Belt Start and Stop Time Validation

- Purpose: Validate the running belt Start time duration for speeds 0 km/h up to maximal of 7 km/h, and Stop time of the running belt from a speed of 7 km/h down to 0 km/h. examining performances with maximum load.
- Equipment: Brand ACCUSPLIT, Model 601X, S/N 44587215
- Test Procedure:

1. Use a Stop Watch measurement equipment:

2. Since the load capacity of the BT is 135 kg at the maximum, the subject wears additional cloths so the total weight becomes 140 kg as the worst case. Therefore, we use a subject that simulates a 140Kg load on the BT. Test conducted with two units to confirm that it is not characteristic of the device. The test conducted three times for each device in order to confirm the accidental result at the time of the measurement.

3. Sequence:
   A. Set the BT software to a manual mode
   B. Set speed to 7 km/h
   C. Set treatment duration to 1min
   D. Prepare and reset the Stop Watch
   E. Press PLAY and on the same time start the Stop Watch
   F. When speed reaches to maxima speed of 7 km/h (sound of the motor start to be constant), stop the Stop Watch counting
   G. Write the execution time from the Stop Watch
   H. Reset the Stop Watch and prepare for a second counting
   I. Continue walking for 20-30 seconds more

J. Press STOP and on the same time start the Stop Watch
K. When speed reaches to full stop of the belt, stop the Stop Watch counting.
L. Write the execution time from the Stop Watch
M. Repeat 3 times for all four perturbation directions

4. Repeat above sequence with another BT

❖ Results for the BT100 S/N: A183000007

Record #	**START TIME [sec]**	**STOP TIME [sec]**	**Criteria START: 7 ≤ t [sec] ≤ 10**	**Criteria STOP: 7 ≤ t [sec] ≤ 10**
1	8.15	7.94	Pass	Pass
2	8.08	8.03	Pass	Pass
3	8.22	8.11	Pass	Pass

❖ Results for the BT100 S/N: A183000032

Record #	**START TIME [sec]**	**STOP TIME [sec]**	**Criteria START: 7 ≤ t [sec] ≤ 10**	**Criteria STOP: 7 ≤ t [sec] ≤ 10**
1	8.11	8.04	Pass	Pass
2	8.18	8.10	Pass	Pass
3	8.07	7.89	Pass	Pass

❖ Conclusion:

For both systems, values within the range of the required specification values measured.

4.9 Gait Analysis

The following section will focus on validating gait analysis parameters generated from the Gait Analysis Evaluation mode.

Note: This module is license dependent and not included in the basic BalanceTutor software pack. Ask your vendor for quotation on the Gait Analysis Add-on Module.

4.9.1 Introduction

The BalanceTutor has a real-time data acquisition from four analogue load cells that can hold up to 200Kg of weight for each sensor. The analogue output of the load cells are then digitized (A/D converter) in a rate of 100[sample/sec]. Using a moment calculation of the weights applied on each sensor a COP(x(t),y(t)) calculated. In practice because its sampled time COP function represented as COP(x(nTs),y(nTs)) while n is time index and Ts is the sampling time interval. Because the moment equations makes the total weight applied to the platform equal at any Euclidian point, the weight then is not the parameter for analysis but only the location of the gait event and its timing.

4.10 Reproducibility Test

The gait analysis functionality tested in healthy volunteers. The volunteers walked on the treadmill at speeds 1, 2, 3, 4, 5 and 6 km/h. The volunteers repeated the test 3 times at each speed.

It was found that the values generated over the 3 tests at each speed 1, 2, 3, 4, 5 and 6 km/h were not significantly different. There was an anomaly at test speed 1km/h. The reason for this is thought to be due to the fact that this speed is below a comfortable walking speed. At this speed the volunteer over planned and thought about each step in an unnatural fashion.

The following report shows one example of spatiotemporal parameters of gait during the testing namely Speed, Cadence, Step Length, Step Width, Stride Length, Single Support (% of gait cycle), Double Support (% of gait cycle), Stance phase (% of gait cycle) and Swing phase (% of gait cycle).

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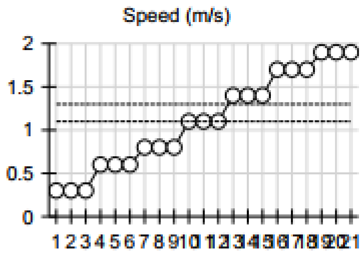
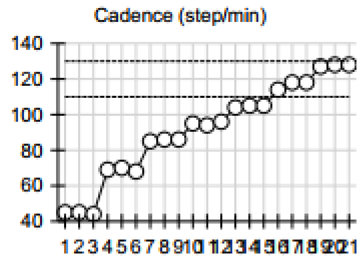
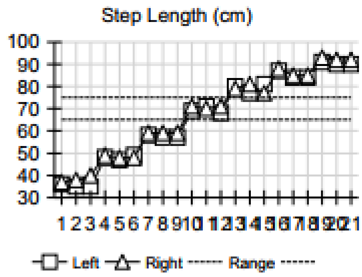
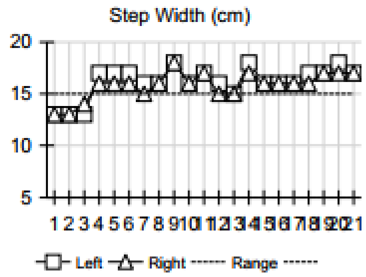
Gait Analysis Report

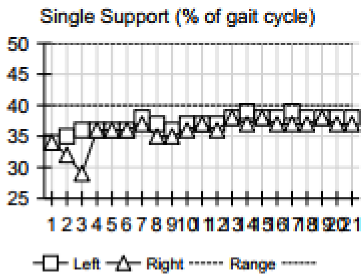
First Name: alan Last Name: alan ID No.: 777777

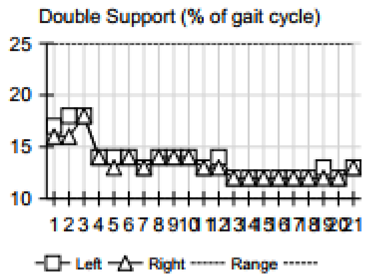












Evaluation was performed on MediTouch BalanceTutor equipment. This Report was undertaken at MediTouch Ltd.. Data is only valid if signed by authorized therapist

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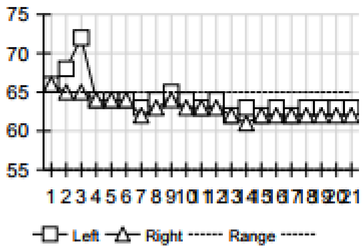
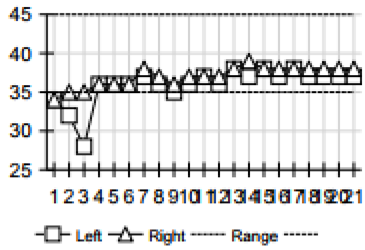
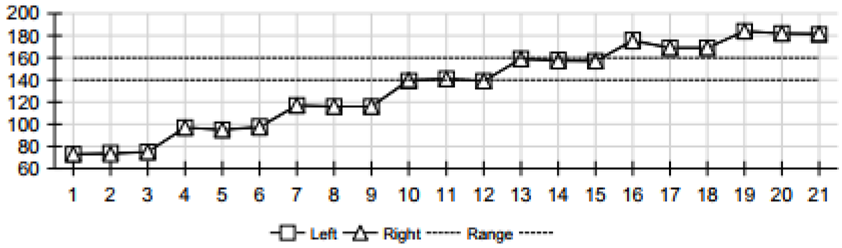
Stance (% of gait cycle)



Swing (% of gait cycle)



Stride Length (cm)



Comments:

Full Name:________________ Signature:________________

Report Guidelines:

This report shows the spatial-temporal parameters of the gait cycle and allows both a comparison between the right and left side and normal values of these parameters at the normal average walking speed during 2min.

Evaluation was performed on MediTouch BalanceTutor equipment. This Report was undertaken at MediTouch Ltd.. Data is only valid if signed by authorized therapist

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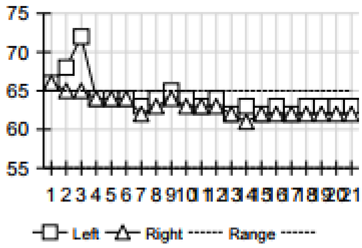
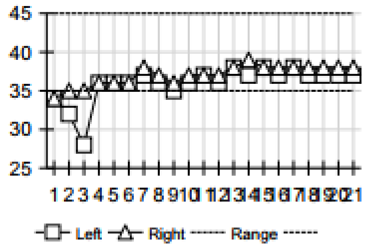
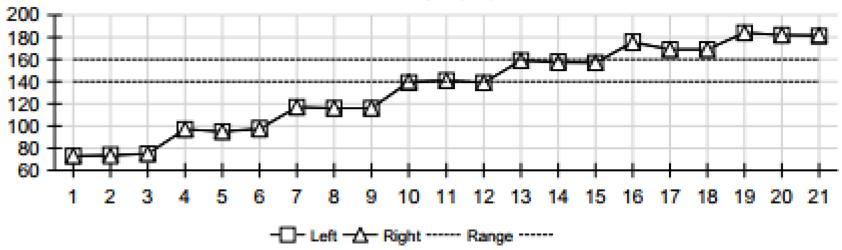
Stance (% of gait cycle)



Swing (% of gait cycle)



Stride Length (cm)



Comments:

Full Name:________________ Signature:________________

Report Guidelines:

This report shows the spatial-temporal parameters of the gait cycle and allows both a comparison between the right and left side and normal values of these parameters at the normal average walking speed during 2min.

Evaluation was performed on MediTouch BalanceTutor equipment. This Report was undertaken at MediTouch Ltd.. Data is only valid if signed by authorized therapist

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