Preprocessing_of_Gait_Dataset

The main objective of this software is to normalise the gait cycles of the right and the left lower limbs of the patients within the Plug-In Gait Model. Firstly, the gait cycle's data in .c3d format is converted to .mat format (the structures *Events.mat* and *Markers.mat*). Secondly, the gait cycles stored in the structure *Markers.mat* are normalised using the time marks saved in the structure *Events.mat* and stored into a matrix in .csv format.

Folder *Preprocessing_of_Gait_Dataset* contains the primary function *normalised_gait_cycles.m* and the subfolder *Libs*.

The primary function *normalised_gait_cycles.m* serves to pre-process the gait cycle's data. MATLAB structures *Events.mat* and *Markers.mat* are the input variables, and the normalised gait cycles saved to .csv files are the outputs. Both MATLAB structures (*Events.mat, Markers.mat*) can be generated by *Vicon Nexus* directly or can be gained by a convertor of .c3d data to .mat format that can be downloaded from the website *https://github.com/RehabEngGroup/MOtoNMS*. On this website, the user finds a convertor (*MOtoNMS*), an instruction for the installation, and the software requirements (a version of MATLAB, etc.).

The structure *Events.mat*

- must contain seven-time marks (or five-time marks if the lower limbs were acquired separately) at least and four fields for the precise determination of the gait cycles, otherwise the primary function notifies the error.

The structure *Markers.mat*

- must contain a matrix of variables describing the gait cycle into the frontal, the sagittal, and the transversal planes
- should contain the markers and the gait variables that are used for the Plug-In Gait Model (a detailed description of the markers and the gait variables of the Plug-In Gait Model is introduced in the section *Gait Variables' Explanation below*).

Example of *Events. mat and Markers. mat* is shown below.

Events

1x7 struct with 4 fields

Fields	label	context	time	frame
1	'Foot Strike'	'Right'	0.5833	71
2	'Foot Off'	'Left'	0.6500	79
3	'Foot Strike'	'Left'	1.0250	124
4	'Foot Off'	'Right'	1.1083	134
5	'Foot Strike'	'Right'	1.5417	186
6	'Foot Off'	'Left'	1.5833	191
7	'Foot Strike'	'Left'	1.9583	236
8				
9				

Figure 1 Example of 'Events.mat'

In Figure 1 the structure *Events.mat* is introduced. It contains seven-time marks (in column *label*) corresponding with the gait cycles of the right and the left lower limb and four fields (*label*, *context*, *time* and *frame*).

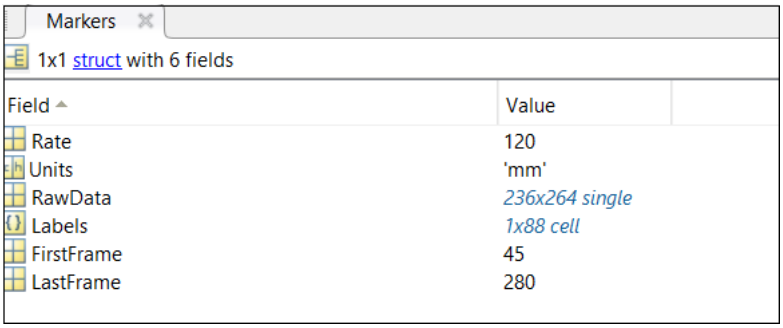

Figure 2 Example of 'Markers.mat'

In Figure 2 the structure *Markers.mat* is introduced. The names of the markers and the gait variables are saved in the field *Labels* and the gait variables are stored in the field *RawData*. Each marker and the gait variables are captured in the three-dimensional space, x-axis (in the direction of the gait), y-axis (from the left side to the right side) and z-axis (the vertical axis) that corresponding with the frontal plane (x-axis is perpendicular to the frontal plane), the sagittal plane (y-axis is perpendicular to the sagittal plane) and the transversal plane (z-axis is perpendicular to the transversal plane).

The Plug-In Gait model is a basic model for the gait investigation, but it is possible to extend the Plug-In Gait Model using more markers mounted on the lower limbs (additional markers of the extended Plug-In Gait Model are introduced in the section *Gait Variables' Explanation* below).

The primary function *normalised_gait_cycles.m* can be run via the command window by using the command ***matlab /r " normalised_gait_cycles('path of input data','path of output data')"***. The primary function *normalised_gait_cycles.m* comprises 5 separate functions that are stored in subfolder *Libs*.

Subfolder *Libs* contains 5 separate functions:

- *recurse_subfolders_R2016b.m* is the function that creates the list of the input data
- *bounding_of_gait_cycles.m* is the function that determines the beginning and the end of the gait cycles for both lower limbs, the structure *Events.mat* is the input of this function
- *selection_of_gait_cycles_variables_left_limb.m* is the function that determines the gait cycle' variables which describe the gait cycle in the frontal, the sagittal and the transversal planes for the left lower limb, the structure *Markers.mat* is the input of this function
- *selection_of_gait_cycles_variables_right_limb.m* is the function that determines the gait cycle' variables which describe the gait cycle in the frontal, the sagittal and the transversal planes for the right lower limb, the structure *Markers.mat* is the input of this function
- *title_of_normalised_gait_cycles.m* is the function that names the final output data by our specific format (our specific format: *"<LastName>-<FirstName>-<YearOfBirthInFormat:YY>-<DateOfExaminationInFormat:DDMMYYYY>-Cal-<GaitCycleNumber>-<LimbType:L|R>"*)

GAIT VARIABLES' EXPLANATION

MARKERS AND GAIT VARIABLES OF PLUG-IN GAIT MODEL

MARKER	DESCRIPTION	UNITS
LASI	LEFT top hip spine	mm
RASI	RIGHT top hip spine	mm
LPSI	LEFT back hip spine	mm
RPSI	RIGHT back hip spine	mm
LTHI	LEFT thigh	mm
LKNE	LEFT knee	mm
LTIB	LEFT tibia	mm
LANK	LEFT ankle	mm
LHEE	LEFT heel	mm
LTOE	LEFT toe	mm
RTHI	RIGHT thigh	mm
RKNE	RIGHT knee	mm
RTIB	RIGHT tibia	mm
RANK	RIGHT ankle	mm
RHEE	RIGHT heel	mm
RTOE	RIGHT toe	mm

VARIABLE	DESCRIPTION	UNITS
LHipAngles	LEFT limb, relative, angles between pelvis and thigh	degree
LKneeAngles	LEFT limb, relative, angles between thigh and tibia	degree
LAnkleAngels	LEFT limb, relative, angles between tibia and foot	degree
LAbsAnkleAngle	LEFT limb, angle between AJC-KJC vector and AJC-TOE vector	degree
RHipAngles	RIGHT limb, relative, angles between pelvis and thigh	degree
RKneeAngles	RIGHT limb, relative, angles between thigh and tibia	degree
RAnkleAngles	RIGHT limb, relative, angles between tibia and foot	degree
RAbsAnkleAngle	RIGHT limb, angle between AJC-KJC vector	degree

	and AJC-TOE vector	
LPelvisAngles	LEFT limb, absolute, angles between pelvis and laboratory coordinate system	degree
RPelvisAngles	RIGHT limb, absolute, angles between pelvis and laboratory coordinate system	degree
LFootProgressAngles	LEFT limb, absolute, angles between foot and global coordinate system	degree
RFootProgressAngles	RIGHT limb, absolute, angles between foot and global coordinate system	degree
LAnklePower	LEFT limb, power (energy) between tibia and foot	W
RAnklePower	RIGHT limb, power (energy) between tibia and foot	W
LKneePower	LEFT limb, power (energy) between thigh and tibia	W
RKneePower	RIGHT limb, power (energy) between thigh and tibia	W
LHipPower	LEFT limb, power (energy) between pelvis and thigh	W
RHipPower	RIGHT limb, power (energy) between pelvis and thigh	W
LGroundReactionForce	LEFT limb, force between foot and ground during the gait	N
RGroundReactionForce	RIGHT limb, force between foot and ground during the gait	N
LNormalisedGRF	LEFT limb, GRF expressed in percentage due to the weight of the body	%
RNormalisedGRF	RIGHT limb, GRF expressed in percentage due to the weight of the body	%
LAnkleForce	LEFT limb, force between tibia and foot	N
RAnkleForce	RIGHT limb, force between tibia and foot	N
LKneeForce	LEFT limb, force between thigh and tibia	N
RKneeForce	RIGHT limb, force between thigh and tibia	N
LHipForce	LEFT limb, force between pelvis and thigh	N
RHipForce	RIGHT limb, force between pelvis and thigh	N
LAnkleMoment	LEFT limb, moment between tibia and foot	N.m
RAnkleMoment	RIGHT limb, moment between tibia and foot	N.m
LKneeMoment	LEFT limb, moment between thigh and tibia	N.m
RKneeMOment	RIGHT limb, moment between thigh and tibia	N.m

LHipMoment	LEFT limb, moment between pelvis and thigh	N.m
RHipMoment	RIGHT limb, moment between pelvis and thigh	N.m
LGroundReactionMoment	LEFT limb, sum of the moments produced by individual reaction forces about the COP	N.m
RGroundReactionMoment	RIGHT limb, sum of the moments produced by individual reaction forces about the COP	N.m

ADDITIONAL MARKERS OF OTHER MODELS (e.g. EXTENDED PLUG-IN GAIT MODEL)

MARKER	DESCRIPTION	UNITS
LFEO	LEFT femur origin	mm
LFEA	LEFT femur anterior	mm
LFEL	LEFT femur lateral	mm
LFEP	LEFT femur proximal	mm
LFOO	LEFT foot origin	mm
LFOA	LEFT foot anterior	mm
LFOL	LEFT foot lateral	mm
LFOP	LEFT foot proximal	mm
LTIO	LEFT tibia origin	mm
LTIA	LEFT tibia anterior	mm
LTIL	LEFT tibia lateral	mm
LTIP	LEFT tibia proximal	mm
LTOO	LEFT toe origin	mm
LTOL	LEFT toe lateral	mm
LTOA	LEFT toe anterior	mm
LTOP	LEFT toe proximal	mm
PELO	virtual marker, pelvis origin	mm
PELA	virtual marker, pelvis anterior axis	mm
PELL	virtual marker, pelvis lateral axis	mm
PELP	virtual marker, pelvis proximal axis	mm
RFEO	RIGHT femur origin	mm

RFEA	RIGHT femur anterior	mm
RFEL	RIGHT femur lateral	mm
RFEP	RIGHT femur proximal	mm
RFOO	RIGHT foot origin	mm
RFOA	RIGHT foot anterior	mm
RFOL	RIGHT foot lateral	mm
RFOP	RIGHT foot proximal	mm
RTIO	RIGHT tibia origin	mm
RTIA	RIGHT tibia anterior	mm
RTIL	RIGHT tibia lateral	mm
RTIP	RIGHT tibia proximal	mm
RTOO	RIGHT toe origin	mm
RTOA	RIGHT toe anterior	mm
RTOL	RIGHT toe lateral	mm
RTOP	RIGHT toe proximal	mm