VPP calculation tool

The file main_calculation.py creates a GUI. The GUI is developed to calculate the Virtual Pivot Point (VPP) easily. If there are problems, please contact me (johanna.vielemeyer@uni-jena.de) or optimize the code by yourself.

1 Preparation

1.1 Installation

You have to install *python3* and you need the following packages:

- configparser
- matplotlib.pyplot
- numpy
- os
- scipy
- tkinter

1.2 Input data

The data set for ramp walking is saved at FigShare repository. If you want to use your own data set, you should take note of the following:

For VPP calculation you need

- kinetic data from force plates:
  - ground reaction forces (GRF) of
    - x (anterio-posterior, in walking direction) and
    - z (vertical to walking direction) and
  - center of pressure (CoP) in x direction and
  - the mass of the subject (measure at standing)
- kinematic data from 3D video system:
  - Marker position of the following joints/ anatomical landmarks:
    - toe,
    - malleolus lateralis,
    - malleolus medialis,
    - epicondylus lateralis femoris (knee),
    - trochanter major (hip),

        * acromion (shoulder),
        * epicondylus lateralis humeri (elbow),
        * ulnar styloid proc. (wrist) to calculate the center of mass (CoM)
    - or CoM calculated by model

File format

- the input files should be stored in txt
- kinetic and kinematic data could be stored in separate files or in one single file
- it is helpful to name the files according to a system similar to the sample data (e.g. code for subject + number)

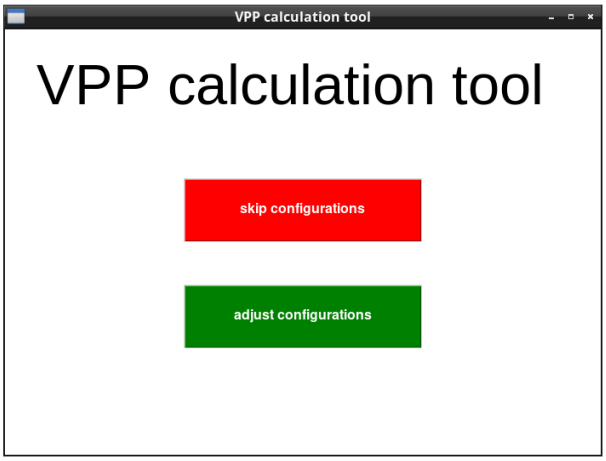
1.3 Start in terminal

cd *location of main_ calculation.py*
python3 main_calculation.py

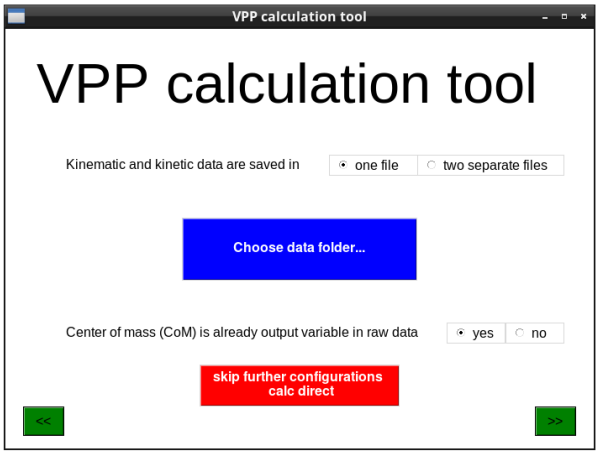
2 Starting page

If you want to change parameters of the GUI, click on “adjust configuration”. Then you will see the next page (section 3).

If you do NOT want to change parameters, click on “skip configurations” (if you use the given data set, you can choose this way) and go directly to the result page (compare section 4.5)



3 Load Data page



1. choose whether kinetic/kinematic data are saved in one ore in two files (for this data set, “one file” is needed; if you have to files for each trial, make sure that the data are synchronized in pairs)

2. Load data folder

3. choose if CoM is already included in raw data or has to be calculated (choose "yes" for this data set)

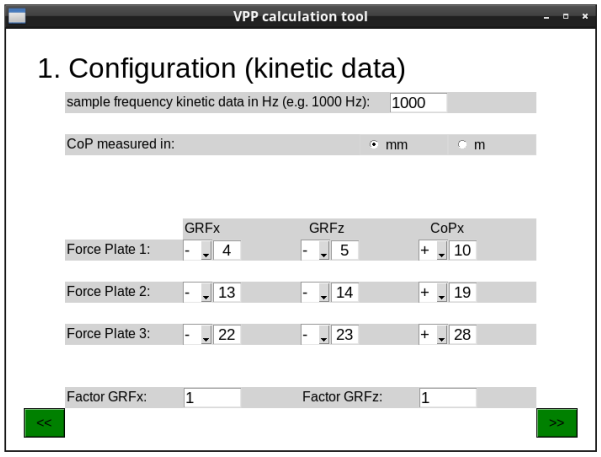
4. go further

   (a) press green arrow → next page (configuration pages)

   (b) press "skip configuration" to skip the next four pages (if you use the given data set, you can choose this way) and go directly to the result page (compare section 4.5)

4 Configuration pages

4.1 Configuration (kinetic data)

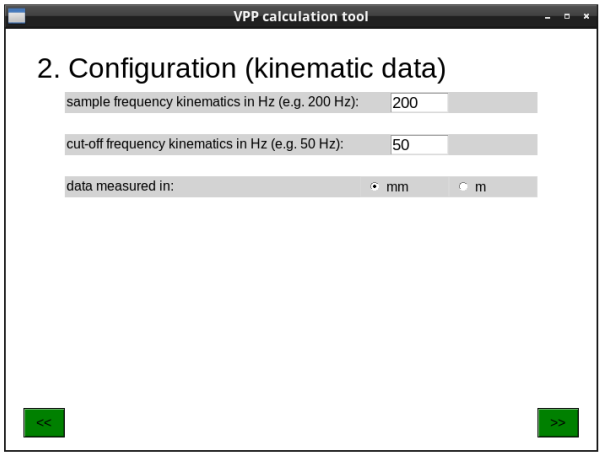


1. sample frequency: measurement frequency of ground reaction force plates

2. which column contains the GRF in anterior-posterior (x) direction etc. of the first force plate (e.g. column 11, start counting at 1), sign: direction of the forces (+: direction fits, - direction has to be mirrored)

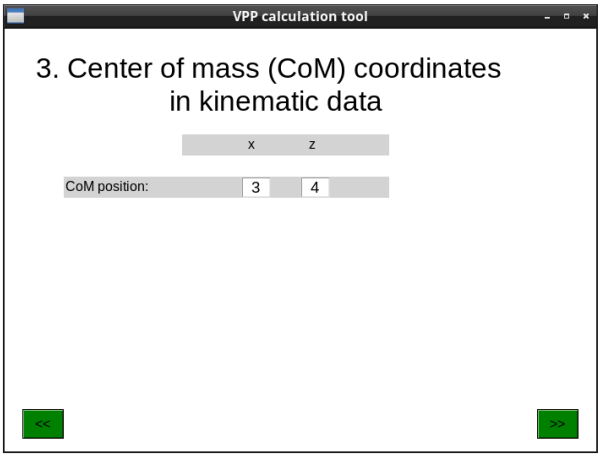
3. factor GRF: Here you can change the amplification of the ground reaction forces in the two different dimensions (standard values are "1.0")

4.2 Configuration (kinematic data)



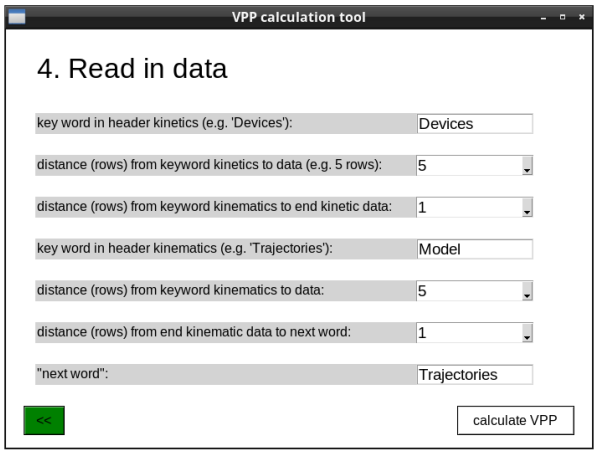
1. sample frequency: measurement frequency of camera system
2. cut-off frequency: filter frequency of kinematic data (CoM data), a bidirectional fourth-order butterworth filter is used (only relevant if CoM is not part of the raw data)

4.3 CoM or marker setup coordinates



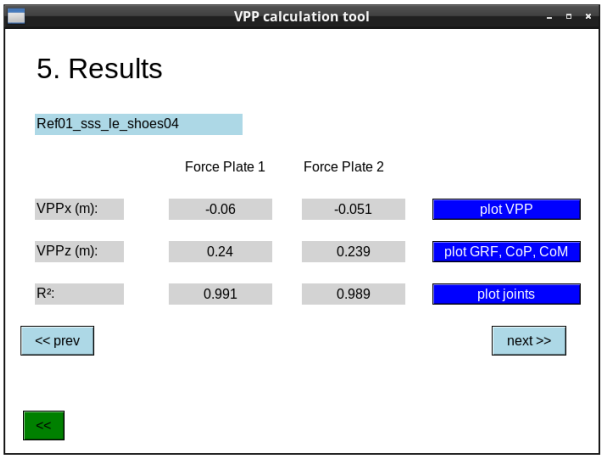
1. If CoM is part of the raw data: give the column of the CoM in the kinematic data file (start counting at 1)
2. If CoM is NOT part of the raw data: give the column of the particular markers (start counting at 1)

4.4 Read in data



- find headers of data file to exclude them for read in data
- press "calculate VPP" to go the result page

4.5 Results



1. you see results of one trial:
   (a) VPP data of one file (file name in blue field on the left side): VPPx, VPPz and R^2 of two consecutive steps are shown
   (b) "plot VPP" creates VPP plot of this trial (the coordinate system is centered to the center of mass (zero, black plus), x-axis: horizontal VPP-position in meter (and horizontal part of the ground reaction forces), y-axis: vertical VPP-position in meter (and vertical part of the ground reaction forces), lines (black to blue): ground reaction

force vectors for different single measurement time points for the single support phase of the contact (that means from toe off of the other leg to the touch down of the other leg), starting at center of pressure, red cross: calculated VPP position)

(c) "plot GRF, CoP, CoM" creates single trial plots in x and z direction for first and second contact (single and double support phases are marked)

(d) "plot joints" creates plot of

i. angle of head, thorax, shoulder, elbow, hip, knee and ankle (ipsi- and contralateral) and

ii. moment and power of hip, knee and ankle

(e) with "prev" and "next" you can switch between the files

2. additional created:

(a) "VPP_Data.csv" contains VPP values for each file

(b) compressed (*npz) calculated data of each file

5 Software adaption

If you want to calculate the VPP concerning the hip instead of the CoM, change the variable "center_of_coord" in "calcButton.py" in the functions "button_res_both" (for calculation) and "plot_vpp" (for plot). If the coordinate system should not be vertically aligned, but trunk aligned, you have to change the variable "aligned" from 0 to 1 in the same functions as mentioned above.

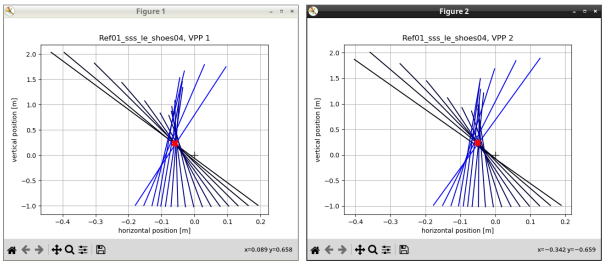


Figure 1
Ref01_sss_le_shoes04, VPP 1
vertical position [m]
horizontal position [m]
x=0.089 y=0.658
Figure 2
Ref01_sss_le_shoes04, VPP 2
vertical position [m]
horizontal position [m]
x=−0.342 y=−0.659

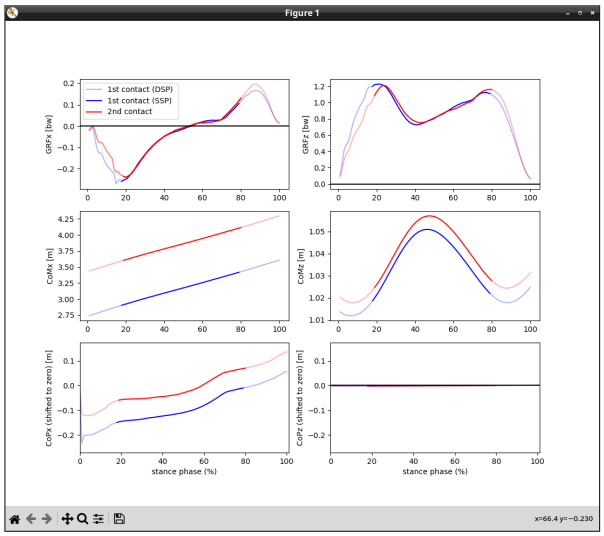


Figure 1
1st contact (DSP)
1st contact (SSP)
2nd contact
GRFx [bw]
GRFz [bw]
CoMx [m]
CoMz [m]
CoPx (shifted to zero) [m]
CoPz (shifted to zero) [m]
stance phase (%)
stance phase (%)
x=66.4 y=−0.230

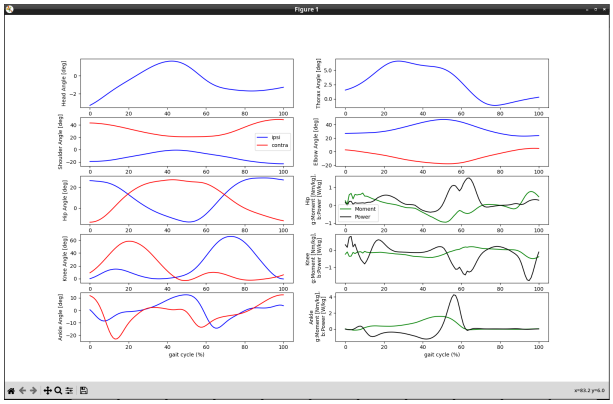


Figure 1
Head Angle [deg]
Thorax Angle [deg]
Shoulder Angle [deg]
ipsi
contra
Elbow Angle [deg]
Hip Angle [deg]
Hip Moment [Nm/kg], Hip Power [W/kg]
Moment
Power
Knee Angle [deg]
Knee Moment [Nm/kg], Knee Power [W/kg]
Ankle Angle [deg]
Ankle Moment [Nm/kg], Ankle Power [W/kg]
gait cycle (%)
gait cycle (%)