Manual ActivPAL Algorithm

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Aim

This algorithm has been developed to automatically identify wake and bed times in 24 h activPAL data on an individual level on multiple days up to 7 days in total (i.e., different wake and bed times, for each day, for each participant).

The accuracy of this algorithm was examined by comparing wake and bed times estimated by the algorithm with self-reported wake and bed times, using a subsample of The Maastricht Study. It has been shown that the algorithm achieved high levels of agreement.[1] A detailed description of the algorithm can be found elsewhere.[1]

Content

This manual provides directions on how to run the algorithm to generate wake and bed times as well as several activity parameters. A full description of all parameters can be found in the dictionary *Maastricht Study Dictionary Accelerometry Variables MATLAB.xls*. In brief, these include:

- Wake and bed times
- Waking time
- Sleep time/"time in bed"
- Sedentary time, sedentary bouts, sedentary breaks, sedentary transitions
- Standing time, standing bouts
- Stepping time, stepping bouts
- Activity score, METs score
- Step count
- Step intensity

Further wake and bed times could manually be adjuted. Directions on how to make corrections in wake and bed times are provided in this manual. Finally, an overview on additional options is provided at the end of this manual.

Step 1

The algorithm runs in MATLAB® (MathWorks. Natick, MA, USA), and uses the *.pal* or *Events.csv* files. This program is made with release 2012a and is tested up to version release 2018b.

Download all files and folders (5 folders: backup_wut_bt (empty), data (empty), excel (empty), figures (empty), matlab (contains files)). Save all *.pal* or *Events.csv* files in individual folders within the data folder.

From the matlab folder, run *start_analyse_activepal_nieuw_uitbreiding.m*. This Graphical User Interface (GUI) will appear (Figure 1).
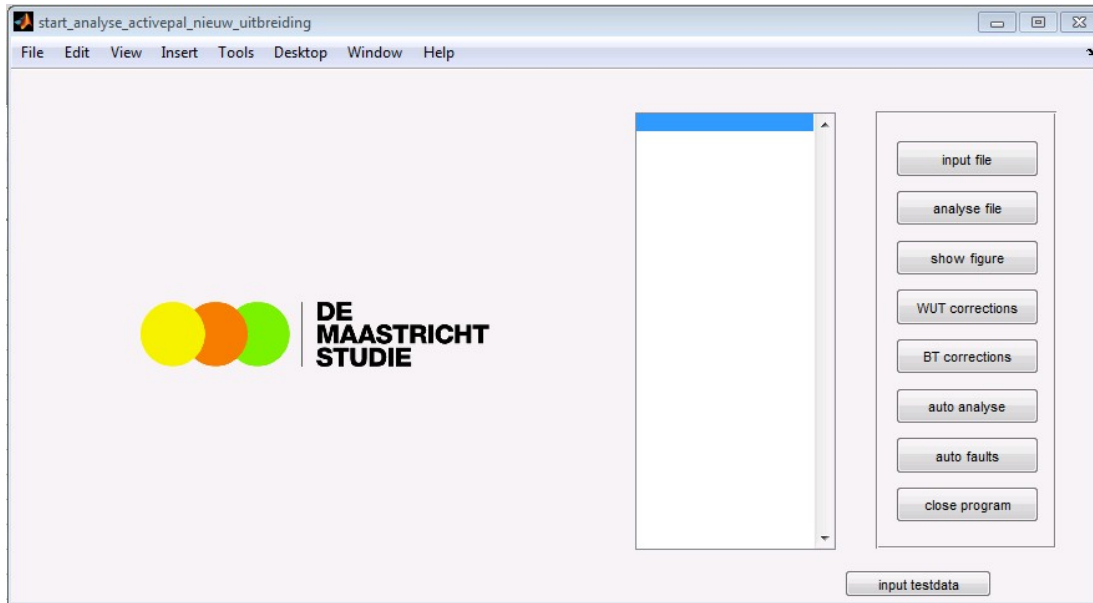
Figure 1: Graphical User Interface (GUI)

Step 2

Single file

To analyse a single file, choose [input file], select the file, and choose [analyse file]. A figure will appear (see Figure 2) and will be saved (*[…].fig*; folder: figures). The generated wake and bed times and the parameters will be saved in an Excel file: *uitvoer.xls* (folder: excel). Each time when a single file is analysed, the generated wake/bed times and the parameters will be added to the Excel file *uitvoer.xls*.
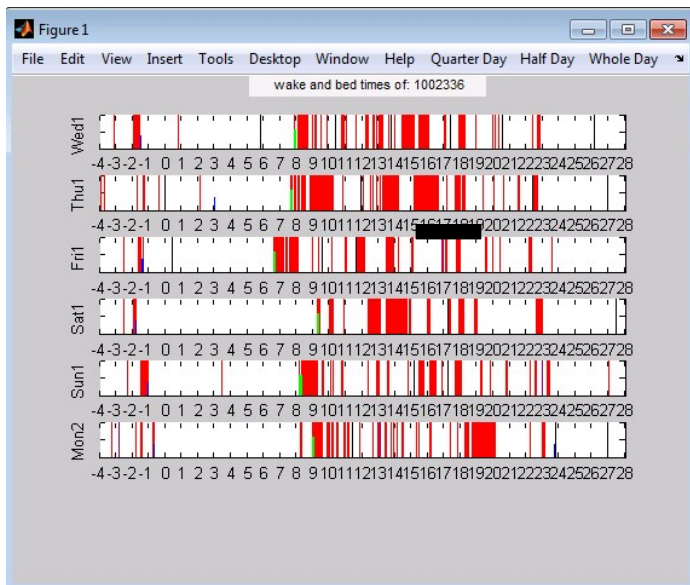

Figure 2: MATLAB figure representing activity, wake and bed time

Note: when running the GUI, all Excel applications should be closed.

The figure can be used to make corrections in wake and bed time. Directions on how to do this are provided in this manual.

<u>Multiple files</u>

To analyse multiple files, choose [auto analyse] and select the folder data with the files. Then choose a file name and location for the Excel file that will be generated. MATLAB will automatically analyse all files and save the output in the Excel file. The figures of all files will also be saved (*[…].fig*; folder: figures).

      Note: when running the GUI, all Excel applications should be closed. Please also close all figures before running the GUI.

      Note: due to limitations of Excel, at most 1,200 files could be analysed at the same time. This will last several hours, as >5,000 parameters will be calculated for each file.

The files with limited amount of data will not be analysed. The command window of MATLAB will then show: "*file: […] heeft maar 0 analyse dagen*" [→*File has 0 days of data*]. In the Excel file, the row of the corresponding *.pal* file will be filled with zeros.

When the GUI cannot analyse a file due to the non-wear criteria listed below, (for example large amount of time is spent in one activity (e.g. sedentary, standing, stepping)), the row of the corresponding file in the Excel file will be filled with zeros, but the ID number will be similar to that of the file of the row above.
Non wear criteria:
•   No change in activity for 12h or more
•   Sedentary for more than 7 hours between 08u00 and 18u00
•   Active for 7 hours or more starting between 0u00 and 06u00

In both cases (limited amount of data and measurement errors), MATLAB will create a file that lists the errors: *foute_files.mat*. This table could be opened by choosing [auto faults]. The table provides information on the type of error by providing the following information:
Limited amounts of data: "*Undefined function ''aant_wear_days_is_nul'' for input arguments of type 'double'* ".

Measurement error: the information depends on type of error. Measurement errors could best be seen using the activPAL software. Common errors include:
"Matrix dimensions must agree"
"Subscript indices must either be real positive integers or logicals"
"Invalid file identifier. Use open to generate a valid file identifier"
"Index exceeds matrix dimensions"
"In an assignment A(I) = B, the number of elements in B and I must be the same" *"Attempted to access ind_neer(0); index must be a positive integer or logical"*

Wake and bed times corrections

To make corrections in the estimated wake and bed times, for each file a figure (see Figure 3) will be generated and saved (*[…].fig*; folder: figures). To view the figure, choose [show figure].
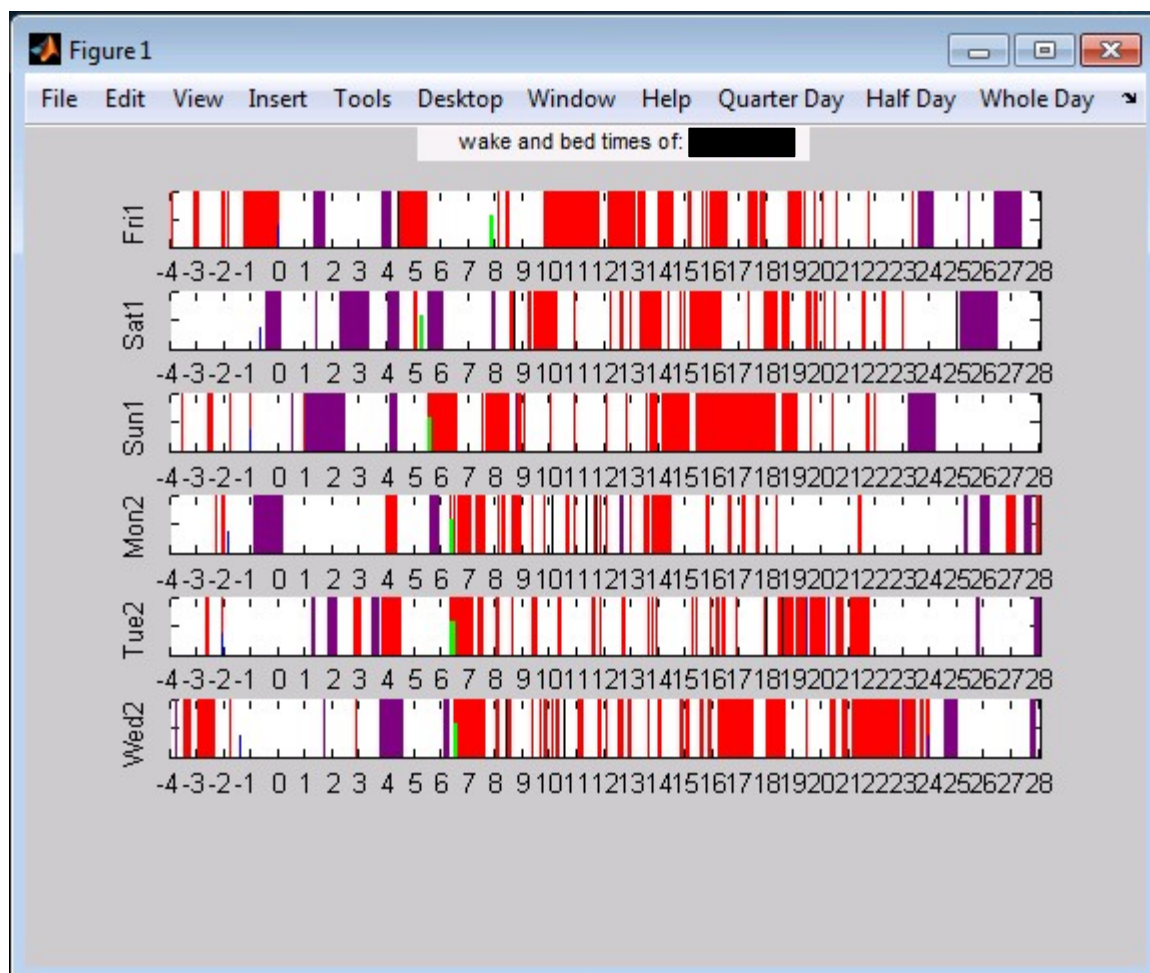

Figure 3: MATLAB figure representing activity, wake and bed times

Each row represents a day of measurement. For example, Wed1 represents the first Wednesday of the activPAL measurement period.

On the X-axis daytime is presented from 20:00h (-4) on the day before until 04:00h (28) the day after. For example: Wed1 is represented from Tuesday 20:00h until Thursday 04:00h. Consequently, hours 22-28 on Wed1, are similar to hours -4-0 on Thu1.

The red bars represent activity (standing and stepping). Activity periods with a duration less than 1 minute will be expanded with a black bar for a better visualisation.
The purple bars indicate standing time without stepping.
The green bars indicate waking time; the blue bars indicate bed time.
To zoom in: choose [Quarter Day] or [Half Day].
To zoom out: choose [Whole Day].

Corrections in wake and bed times can be made by clicking on a green or blue bar and dropping the bar at a chosen point in time. It is not necessary to drop the green bars exactly at the beginning of an activity period (red bars) – MATLAB will automatically set wake time at the first second of the selected activity period, which will then be indicated as wake time (Figure 4). A similar procedure applies for bed time – MATLAB will automatically set bed time at the last second of the selected activity period, which will then be indicated as bed time
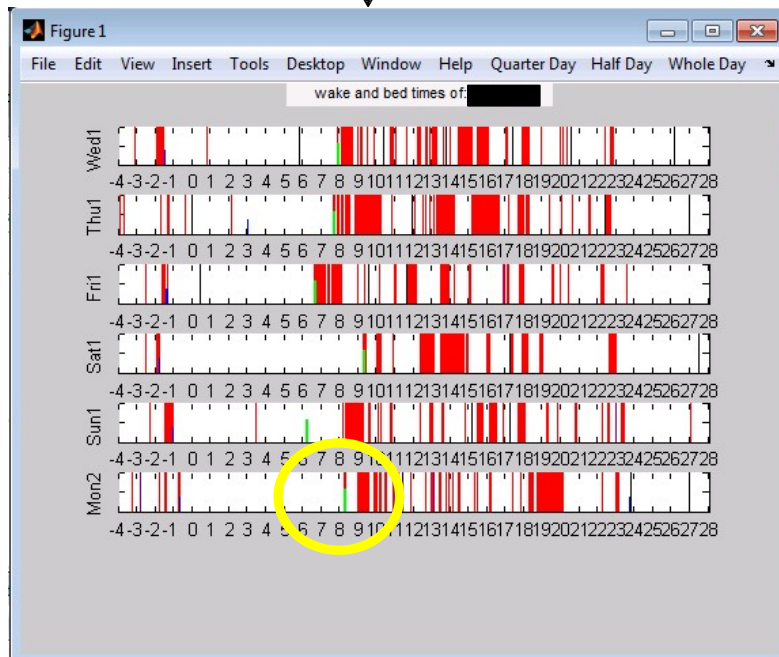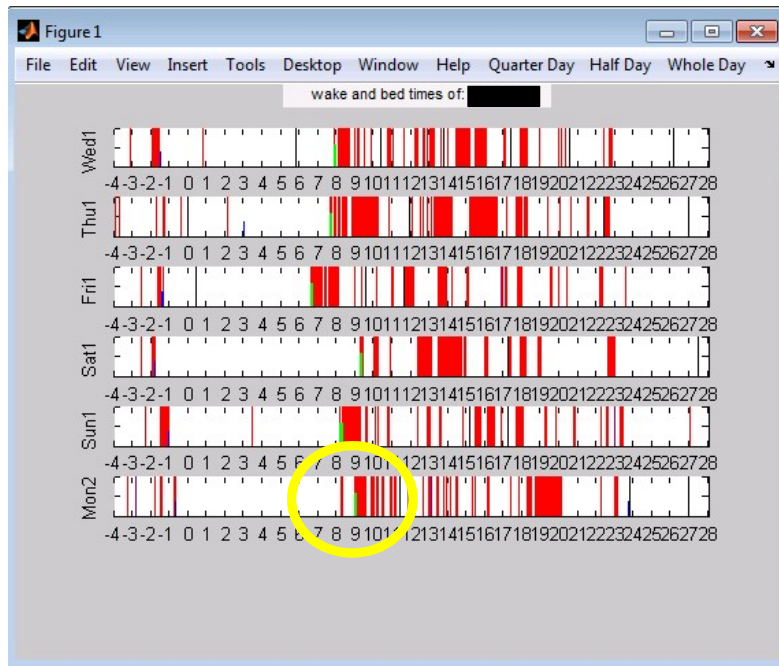

Figure 4: Correction in wake time.

MATLAB will automatically save the corrections in wake and bed times (*database_wut_[..].mat or database_bt_[..].mat*). An overview of the corrections can be seen by choosing [WUT corrections] or [BT corrections] (Figure 5).

The corrections in wake/bed times will automatically be used, each time when running the GUI. Please close all figures before running the GUI. To remove corrections, select and right-click the correction that should be removed (Figure 5).
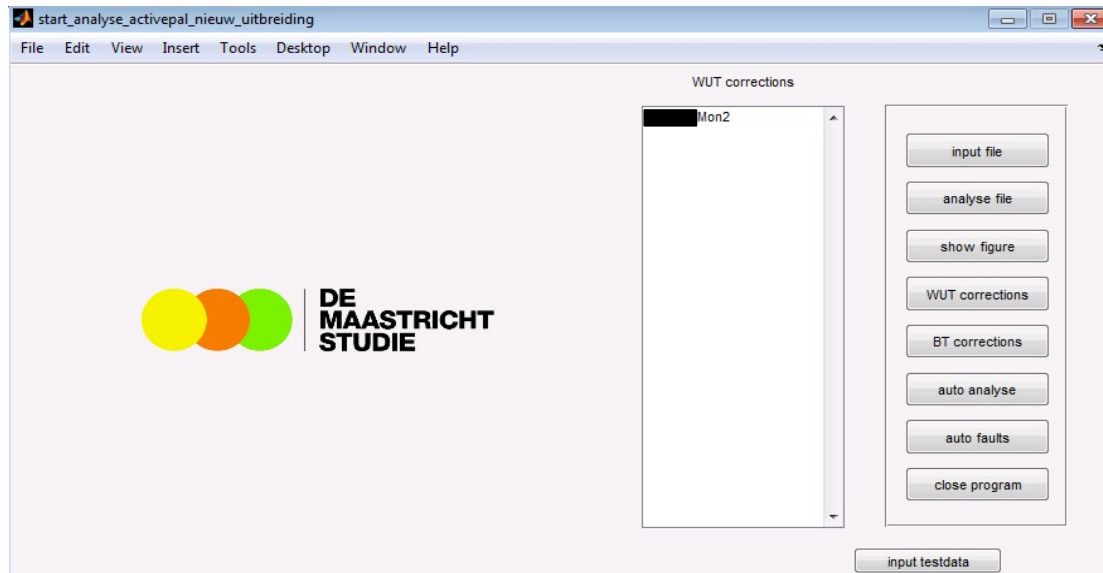

Figure 5: Correction in wake time.

Additional options
To test whether the GUI generates data as expected, it is possible to analyse test data. Choose [input testdata] and [analyse file]. A figure of the test data will appear and will be saved (*[…].fig*; folder: figures). The generated wake/bed times and the parameters will be saved in an Excel file (folder: excel).

Contact information
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Reference
1. van der Berg JD, Willems PJ, van der Velde JH, Savelberg HH, Schaper NC, Schram MT, Sep SJ, Dagnelie PC, Bosma H, Stehouwer CD, Koster A: Identifying waking time in 24-h accelerometry data in adults using an automated algorithm. J Sports Sci. 2016; 2:1–7.