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Introduction

Originally titled “Helen Hayes Hospital - Software for Bilateral Gait Analysis” this collection of software programs was written by H.K.Ramakrishnan under the direction of Dr. Murali Kadaba and Mary Wooten at the Orthopaedic Engineering and Research Center of Helen Hayes Hospital in West Haverstraw, New York. The applications, originally written for the Digital Equipment Corporation (DEC) RSX11M 16-bit operating system, were largely complete by 1988 but were later extensively modified to support the more powerful DEC 32-bit VAX/VMS range of computers. Some versions of the last releases of source code contain copyright dates from 1988 through 1990 showing the code owned by Health Research Incorporated and the Helen Hayes Hospital although most of the software modules were originally written and distributed without any copyright information several years earlier.

This manual has been created, in large part, based on the published notes and text files supplied several versions of the Helen Hayes Software that were distributed as part of a research project to gather clinical gait data from children with cerebral palsy. As a result of this research project, the software package discussed here was widely distributed in the United States with Vicon 3D data collection systems manufactured by Oxford Metrics Ltd. Initially the software ran under the Digital Equipment Corp (DEC) RSX11-M system, using the data files created by the original Vicon system (ADC, FPD, TR3 etc), but later versions of the software were modified to provide rudimentary support for C3D files created using ADtech AMASS software.

The software applications comprising the Helen Hayes Software were written in ISO standard Pascal and compiled using the Oregon Software Pascal-2 complier. Like the original Vicon software, the various applications comprising the Helen Hayes software suite were supplied as source code and were often modified and re-compiled to meet the specific configuration at each installation location. Users were expected to read the source code if they needed more information. Other than a few short ASCII text files, no documentation was supplied with the software since this was a research project and not a commercial package. As a result of the Helen Hayes Software source code being widely distributed most modern Gait Analysis software programs are descended from this original suite of programs.

This manual is a private effort and is not officially sanctioned by either Helen Hayes Hospital or Health Research Inc. The manual has been written to provide an introduction to the use and operation of Helen Hayes Software for Physical Therapists and Clinicians with the responsibility of running a gait analysis lab using the Helen Hayes Software. This version is an attempt to pull together all of the
documentation files supplied with the software into one document and provide a roadmap for users of the various versions of the software.

**Helen Hayes Hospital**

One of the country’s first physical rehabilitation facilities, Helen Hayes Hospital is widely recognized as a leader in rehabilitation medicine and research. Located just outside West Haverstraw, a half hour drive north of New York City, Helen Hayes Hospital offers care and specialty rehabilitation services to patients with stroke, traumatic brain and spinal cord injuries, neurological, cardiopulmonary and orthopedic disorders.

**Health Research Inc.**

Health Research, Incorporated ([http://www.hrinet.org](http://www.hrinet.org)) is a not-for-profit corporation affiliated with the New York State Department of Health and the Roswell Park Cancer Institute, a leading cancer research center located in Buffalo, NY. Its mission is to evaluate, solicit, and administer external financial support for projects, and to disseminate the benefits of Department of Health expertise through programs such as technology transfer. Health Research Incorporated is a not-for-profit corporation organized under the New York State not-for-profit Corporation Law.

**Capabilities**

The Helen Hayes Software is capable of calculating and printing/plotting:

- Gait events and gait parameters from the footswitch-analog data.
- Ground reaction forces, center of pressure and ground reaction torque from the AMTI force plate data.
- Lower extremity rotation angles of the Pelvis, hip, knee and ankle relative to ground or relative to the proximal segment.
- Gait cycle based electromyographical activity.

All of the programs supplied as part of the Helen Hayes Software suite perform one or more of these functions, allowing the process of gait analysis to be divided into a number of sub tasks, each of which can be performed individually. This approach allowed the analysis process to be paused and inspected at any time to correct any errors or fix problems with the data. The Helen Hayes Software was widely distributed and used, being generally considered to be much easier to use than the Boston Software released by Dr. Sheldon Simon of Boston Children’s Hospital and distributed by Oxford Metrics Ltd., some four years earlier.

**Requirements**

The Helen Hayes Software was originally written independently for use with data files created by 3D motion capture system based on research at the University of Strathclyde, Glasgow by Professor John P. Paul and his PhD students, Michael Jarrett and Brian Andrews. This is described in *A television/computer system for human locomotion analysis. PhD thesis, Jarrett MO (1976)* which led to the development of a video camera based motion capture system by manufactured and sold by Oxford Metrics Ltd in Oxford England. Only the data files created by the VICON system are read by the Helen Hayes Software programs – as a result it is not necessary to have the VICON software installed in the computer where this data analysis is going to take place.
The Helen Hayes Software was never made commercially available but Helen Hayes hospital supplied the software to many VICON users in the United States who used the package as part of a research program to collect data from subjects with Cerebral Palsy. Later versions of the Helen Hayes software supported reading 3D and analog information directly from C3D files, allowing the software to be used with data from any 3D data collection system that supports the public domain C3D standard (https://www.c3d.org).

3D Marker Placement

The motion data for analysis by the software must be collected with the marker configuration proposed in this project and described in the paper 'Lower extremity kinematics during level walking' (Kadaba, Ramakrishnan, Wootten) published in the Journal of Orthopaedic Research in May, 1990.

The original Helen Hayes marker system was designed with a minimum of markers to keep the computerized reconstruction, and manual identification, of the marker trajectories easy for the operators. Due to the limited space available at the Helen Hayes gait lab the initial marker set used by the software was unilateral with markers placed on the pelvis and one leg – initially bilateral data sessions required that data was collected from each side in two separate trials. Later versions of the software added the ability to process bilateral gait data in a single trial.

The Helen Hayes model defines the pelvis with two markers are placed on the right and left anterior superior iliac spines (ASIS) with a third marker on a stick 10 cm long extending from the top of the sacrum (L4-L5) and in the spinal plane. This third marker is stabilized by a flexible triangular plate attached to the body with an elastic belt or hypoallergenic paper tape.

Four other markers are placed on the subject skin surface at the following locations to define the limb. The greater trochanter and a knee marker directly lateral to the estimated average axis of rotation of the knee joint. The foot is defined by two markers on the foot, one on the lateral malleolus and a second over space between the second and third metatarsal heads.

Two additional markers on 70mm wands are secured by cuffs and placed on the mid-thigh and the mid-shank, aligned laterally with the long axis of bones to reflect the neutral rotation angles while standing in a normal position and aligned so that they are in line with the flexion-extension axis of each the corresponding distal segment.

Analog Data

Two AMTI force plates are necessary to generate X-Y-Z force and moment data for the calculations of foot-floor reaction forces and joint moments. Analog force plate data should be low pass filtered at 6Hz by the AMTI force plate amplifier to smooth the plotted force and moment plots.

Foot switches are necessary to identify gait events and to calculate gait parameters based on them. If foot switches are not used then the foot-floor contact points that define the gait cycle must be identified by some other means while processing the data. This is usually done visually with the operator manually recording the 3D video frame numbers during the trajectory identification process for initial contact, toe off, and end of cycle and then entering them as required later in the analysis process.

A multi-channel EMG system is required for the electromyographical analysis with the EMG data recorded at a rate of at least 10 analog samples per video frame for a minimum EMG bandwidth of 300Hz.
Naming Convention of Major Programs

The names of all bilateral programs end with the letter B.

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<th>Name</th>
<th>PURPOSE</th>
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<td>FPCPLOTB</td>
<td>Force Plate Plotting only</td>
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<td>.ADC</td>
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<tr>
<td>ACSB</td>
<td>Angle Calculation Static (condyle &amp; malleoli markers)</td>
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<tr>
<td>APB</td>
<td>Angle Plotting</td>
<td></td>
</tr>
<tr>
<td>APGB</td>
<td>Angle Plotting (One angle at a time)</td>
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<tr>
<td>TEMB</td>
<td>Creates a temporary file necessary for plotting angles</td>
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<td>PGAITPB</td>
<td>Print GAIT Parameters</td>
<td></td>
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<tr>
<td>PANGLEB</td>
<td>Print ANGLE data</td>
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<tr>
<td>PFORCEB</td>
<td>Print FORCE data</td>
<td></td>
</tr>
<tr>
<td>RADCB</td>
<td>Read ADC data of any two channels</td>
<td></td>
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Directories

VICON Data files

When the data files are collected using an RSX11M based VICON system, the trial datasets (TR3, ADC and FPD) are generally stored in the VI2:[300,100] directory which is the default data collection directory on RSX11-M based VICON systems but the software can be used even if the data is located in a different directory.

During the first run, the VICON data directory location is requested and the location is stored in a text file - subsequent runs of the Helen Hayes Software will read this text file to determine the VICON data directory.

Data files collected using a VMS based VICON system will usually be stored as C3D files (containing raw 3D and analog data) in the [VICUSER] directory which is the default data collection directory for VICON-VX 3D motion capture systems.

Software Programs

The RSX11M software programs are located in the directory [1,15]. These programs have extension TSK – indicating an executable task under the RSX-11M operating system. In this directory you will find some Pascal source codes with extension PAS, which may be useful at a later stage for your analysis. You will find lot of RSX11M batch command files with extension CMD which are necessary to run the programs.

The programs themselves can be executed by giving the Monitor Console Routine (MCR) RUN command (e.g. RUN [1,15]XXXX, where XXXX is the name of the program task). To avoid a lot of typing, and the possibility of mistakes, batch command files were created. For example @G is the command equivalent to RUN [1,15]GPGGB which calculates gait parameters. The batch file is an ASCII file so you can use the command TYPE [1,15]G.CMD to see the contents of the batch command file. Under the RSX11M operating system the “@” symbol invokes the MCR command.

The RSX11M operating system command line interpreter is the Monitor Console Routine – usually abbreviated to “MCR”
Also you will find a lot of text files explaining the calculations performed in each of the specific programs. These files have extensions TXT and these can be typed using the MCR command TYPE (Abbreviation T). The names of these files are same as those of the programs themselves. For example if you want to know about the program GPCB which calculates gait parameters, then TYPE [1,15]GPCB.TXT and get a copy of this text file for your reference.

**User directory**

The user can log into any directory on the RSX11M system and run the software, but the Helen Hayes Software programs will all create temporary text files in the current user directory – this reduces the number of data input request during repeated execution of the Helen Hayes Software. So it is better that the user logs into the same RSX11M directory whenever the Helen Hayes Software is used. Each system user can have a separate directory.

Text files are created by the Helen Hayes Software programs (ex. DEV.TXT;1) during the first run. If you want to change or modify the information in the .TXT files, please delete them using the MCR command DELETE. When you rerun a Helen Hayes Software program that needs the files, you will be prompted to enter the information and the files will be created again.

If at any point of time if you want to stop a running program, then press both CTRL-C to escape to MCR and than type ABO to abort the programs. When you are executing multiple runs using the command files (ex. A.CMD) you may have to do this several times to break each program. If you execute a calculation program more than once, the output data files (ex. ANR or FPR) will be overwritten so that only the latest information is stored.

**Calculation sequence**

Calculations for left and right lower limbs are to be done separately and are independent of each other. All calculations and plots are done only for a specified gait cycle. The starting frame for calculation is a foot-floor contact frame of a particular side and the last frame is the next foot-floor contact point of the same side thus defining the gait cycle for the calculations. So, it is very important that the gait events are identified properly before the force and angle calculations are performed.

Therefore, please follow the steps suggested below.

Following command files are available in [1,15].

- G.CMD for gait parameter calculations
- A.CMD for joint angle calculation and plot
- F.CMD for force calculation and plot (If frames <= 120)
- F1.CMD for force calculation only (if frames < 200)
- AG.CMD for joint angles relative to ground
- AS.CMD for calculating rotation angles from condyle markers

Following commands can be used for printing/plotting existing files.

- APRINT.CMD for Printing Angles
- FPRINT.CMD for Printing Forces
- GPRINT.CMD for Printing Gait parameters
- A1PLOT.CMD for Plotting Angles one at a time
As I mentioned, all of the software program tasks are located in the RSX11M [1,15] directory. We strongly suggest you to log into a different directory for running all programs mentioned in this report. Please copy all command files (with extension .CMD) from [1,15] to your directory.

**STEP 1**

**Generate the Gait Parameters**

Type the command @[1,15]G to calculate gait events and parameters. (If you have already copied the command files from [1,15] to your directory then Type @G).

The command file G.CMD in [1,15] reads as follows

```
RUN [1,15]GPCB.
```

As mentioned earlier, this program identifies gait events from the footswitch analog data. Four switches are to be located on each foot, first one on the heel, second on the first metatarsal, third on the fifth metatarsal and the last one on the toe.

All four switch signals from each foot pass through an arithmetic summer and the resulting analog data is stored in the VICON ADC file using one channel for the right foot and a separate channel for the left foot data. Both right and left foot switch data are read by the program GPCB and the gait events (mainly foot contact and foot off) are identified and stored by 3D frame number. Once the 3D frame numbers of the required gait cycle are known, the trajectory information for at least 3 additional 3D frames at both ends of the gait cycle must be identified to subsequently calculate the joint angles.

If for any reason, the analog foot-switch data cannot be used to provide foot contact information then the foot contact and foot off frame numbers must be manually entered in during execution of this program. Gait parameters are calculated in this program from the foot contact timing patterns.

During the first run, you will be asked to input the key information about the subject like leg length, knee width, ankle width, and body weight. The patient information, gait events and gait parameters are stored in a parameter file with extension PER;1 for the right limb data (PEL;1 for the left limb data) in the data directory. This parameter file is in text format so that it can be typed out using the MCR command TYPE. This information is very important for the rest of the Helen Hayes Software programs because the gait events defined here are used by all the subsequent Helen Hayes Software analysis programs.

Raw foot switch data is notoriously unreliable and may contain multiple switch closures for some of the foot switch events – this program incorporates some logical processing to pick the first (good) gait cycle events and only the events for this cycle are stored in the parameter file.

If the starting frame of a gait cycle occurs within first 3 frames of 3D data, then the second gait cycle will be stored in the parameter file. But all the gait events are displayed while running GPCB. So we advise you to run the program GPCB on a printer and save the events so that for any reason if you want to calculate all parameters for a different cycle, it will be useful.

If you need to see the gait parameters at this point, you can type them using the command TYPE VI2:[300,100]XXX.PER:1. (Here XXX is the job which is saved in VI2:[300,100]. PER refers the parameter file corresponds to the right limb data).
This will type only the numbers stored in the file. If you want to know what they are, then run the program PGAITPB (Print GAIT Parameter). For this purpose type the command file @GPRINT (equivalent command RUN [1,15]PGAITPB)

One warning at this point - these gait parameters are not final and could be changed by a subsequent analysis program. There is a possibility that the delay in foot switches may result in a small one, or more, 3D frame shift in identifying gait events. If this happens it will be corrected when you run the Force plate analysis program as explained in the next step.

In addition the velocities, stride lengths, direction of progression of the subject are calculated in the angle smoothing program and they are replaced in the parameter file. We suggest you to run the PGAITPB again, after you complete the analysis of angles and forces to get a final copy of all parameters.

So far we have seen the usage of following two command files.

@G to calculate gait events and parameters.
@GPRINT to print gait cycle events and parameters.

---

**STEP 2**

**Determine the Forces**

Type the command @[1,15]F to calculate ground reaction forces. The command file F reads as follows

```
RUN [1,15]FPCB
```

Now we are running the Helen Hayes Software Force Plate Calculation program. Run this program ONLY if you have good force data. During 3D data collection identify all those runs with good force plate data and also note the particular limb (left or right) which hits the force plate.

Since force calculation is done only for the 3D frames inside the gait cycle, it is necessary to run this program after running the gait parameter program GPCB to determine the gait cycle. If you attempt to calculate the ground reaction forces without running GPCB first to define the gait cycle, then FPCB will create a parameter file by itself, but the gait cycles frame numbers will have to be keyed in manually. The GPCB program calculates the forces and simultaneously plots them but is good only for a maximum of 120 frames of 3D data (two seconds at the standard 60Hz 3D sample rate). The calculated forces will be stored in a file with extension FPR for the right limb and FPL for the left limb in REAL (floating point) format.

Even though the program GPCB has defined the gait cycle to be used for the ground reaction force calculation, the FPCB program will check that the starting point of the defined gait cycle is correct by looking for a small vertical force on the force plate at the start of the gait cycle (defined by heel contact on the force plate). Logic is incorporated in the program to identify the starting frame by checking the vertical force (a force level which is equal to 3% of body weight is used for this purpose).

If necessary, the gait cycle is shifted without altering the length of the cycle. For example, if the foot switches show a cycle from frames 20-70, and if the starting point of vertical force happens at frame 18, then the gait cycle will be adjusted to frames 18-68. The foot off point is also obtained from force plate data and they are rewritten in the parameter file along with recalculated parameters for that run. This is necessary because foot switches often produce gait events that are slightly “late”
due to the foot physically striking the plate before activating the foot switch placed on the subjects’ heel.

This logic is optional in the current version of the program and during data analysis the operator can decide NOT to change the cycle if necessary. (Sometimes the patient may have only partial contact with the force plate and under such conditions it is NOT necessary to change the cycle.)

If for any reason, you need to see the actual numbers stored in the force files with extension FPR(or FPL), run the program PFORCEB. PFORCEB means Print FORCE data. To run PFORCEB, type @FPRINT.

@FPRINT is for printing ground reaction forces.

The force program FPCB can handle only 120 frames of data. If you come across a very slow walking patient, then use the following programs for force analysis.

Program FPC1B for calculating forces (No plotting is done in FPC1B). Use the program FPCPLOTB for plotting the forces. These programs are good for 200 frames of data.

In other words if the number of frames is less than 120, then use FPCB. If the number of frames is greater than 120 then use FPC1B and FPCPLOTB for calculating and plotting separately.

Type the command @F1 to calculate and print ground reaction forces if the number of frames exceeds 120.

Command file F1 reads as

RUN FPC1B
RUN FPCPLOTB

Another command file @FPLOT is available in [1,15].

If you need to plot a force data which was calculated earlier then use the command @FPLOT (which reads as RUN [1,15]FPCPLOTB).

We have seen the usage of following four command files in step 2.

@F for calculating and plotting forces (Nframe<120).
@F1 for calculating and plotting forces (Nframe<200).
@FPRINT for printing forces.
@FPLOT for plotting forces.

---

**STEP 3**

**Calculate the Joint Angles**

Type the command @[1,15]A (to calculate JOINT ANGLES)

The command file [1,15]A.CMD reads as follows

RUN [1,15]GPCB
RUN [1,15]ASB
RUN [1,15]ACB
RUN [1,15]APB
DISABLE DISPLAY

Here four programs are run in sequence.

GPCB  For Gait events and gait parameters
ASB  For Smoothing TR3 data
ACB  Angle calculation program
APB  Angle plotting program

As explained earlier, program GPCB calculates gait events and gait parameters from the footswitch channels of the VICON analog data file. Gait parameters will be stored in a text file with extension PER;1 or PEF;1 in the data directory depending on the particular limb (either Right or Left under consideration). The contents of this parameter file can also be viewed using the MCR command TYPE. This program also creates a temporary file with the job name in the user directory by name TEM.TXT;1. This temporary file is rewritten whenever the program GPCB is run on the terminal. TEM.TXT;1 contains the 29 character job name. (Example \text{VI2:\[300,100]\text{xxxxxxxxx.SMO;2}})

Filter the trajectory data

Program ASB smoothes the raw TR3 coordinates within the gait cycle and saves them in a file with extension SMO in the data directory. This file is a binary file containing REAL format numbers and cannot be typed using the MCR TYPE command.

The ASB program also calculates the velocity, stride length and direction of progression from the smoothed TR3 data and updates the parameter file - PER/PEL. The number of markers and job number are added to the TEM.TXT;1 file.

Calculate the Joint Angles

Program ACB reads the SMO file and calculates the relative joint angles using the Helen Hayes Marker model. The joint angles can be calculated either relative to ground or relative to proximal segment. Relative segment angles will be stored in a file with extension ANR for the right limb or ANL for the left limb in real format in the data directory. Absolute angles (relative to ground) will be stored in a file with extension AAR for the right limb or AAL for the left limb in real format in the data directory.

Answer S for the question about the reference system to get the angles relative to proximal segment (Pelvis relative to ground). This program can also be used for correcting the rotations with condyle & malleoli markers or for correcting the rotations for any other angle appropriate for the user.

Plotting the Results

Program APB plots the angles. The current file can be plotted against any other file in the same job by giving Z and then the file number or it can be plotted alone by answering S (meaning same data) or it can be plotted against normal data obtained from 40 normal adults by answering N, or it can be plotted against any other job by first answering D (different) and then giving that job name.

If you need to plot an existing angle data (without doing the calculation) then use the command @APLOT which reads as follows

RUN TEMB
RUN APB
Here TEMB is an additional small program which creates the necessary temporary files for the program APB. Program APB plots all 11 angles on a single page.

If you need to plot an existing angle data (without doing the calculation) one angle at a time then use the command @A1PLOT which reads as follows

RUN TEMB
RUN APGB

APGB is the program for plotting one angle at a time.

If for any reason, you need to see the actual numbers stored in the angle files with extension ANR (or ANL), run the program PANGLEB. PANGLEB means Print ANGLE data. To run PANGLEB, type the command @APRINT.

@APRINT is for printing angles.

If you need joint angles relative to ground XYZ reference system then use the command @AG

The command file [1,15]AG.CMD reads as follows

RUN [1,15]GPCB
RUN [1,15]ASB
RUN [1,15]ACB
RUN [1,15]APGB

Here four programs are run in sequence.

GPCB For Gait events and gait parameters
ASB For Smoothing TR3 data
ACB The angle calculation program
APGB Angle plotting program (One at a time)

In running angle calculation program answer G (for Ground reference).

In running APGB answer 4,3 for row and column number of the plot to get the foot rotation angles with respect to direction of progression.

Type the command @[1,15]AS (to calculate rotation angles using the condyle & malleoli markers)

The command file [1,15]AS.CMD reads as follows

RUN [1,15]GPCB
RUN [1,15]ASB
RUN [1,15]ACSB
RUN [1,15]APB

Here 4 programs are run in sequence.

GPCB For Gait events and gait parameters
ASB For Smoothing TR3 data
ACSB Angle calculation program which is a different one.
APB Angle plotting program.
A program RADCB is available to see the ADC data from two selected ADC channels. You can read the footswitch data from this program. RUN [1,15]RADCB to read an ADC data file.

We have seen the usage of the following six command files in step three.

- @A for relative segment angle calculation and plotting
- @APLOT for angle plotting (all 11 angles)
- @A1PLOT for angle plotting (one angle at a time)
- @APRINT for printing angles.
- @AG for absolute segment angle calculation and plotting
- @AS for condyles rotation angle calculation and plotting
Calculation Programs

ACB – Angle Calculation Bilateral

The ACB program is the Angle-Calculation Program, which calculates the lower limb rotation angles using the Helen Hayes Marker Model from the smoothed 3-D marker coordinates of the defined gait cycle.

This program must follow the smoothing program ASB which creates the smoothed 3D co-ordinate data and stores it in the xxx.SMO file where xxx is the job name.

If the VICON data files are located in VI2:[300,100], then the program GPCB creates a parameter file with extension PER/PEL in VI2:[300,100] and temporary files TEM.TXT;1 & TEM1.TXT;1 in the user directory, all in text format.

The smoothing program ASB creates a smoothed data file in real format with extension SMO in VI2:[300,100] and a marker sequence data file MAR.TXT;1 for the right limb and MAL.TXT;1 for the left limb in text format in the user directory. Also the PER/PEL and TEM.TXT files are updated in the smoothing program.

The ACB program creates a file of angles (floating point format) with extension ANR/ANL in VI2:[300,100].

Calculation sequence

(Follow the Pascal source code listing of program for more clarity)

PROCEDURE READPARA

1. Open TEM.TXT;1 and read the 35-character smooth data file name, FNAME.

2. Get PAF filename (NAME35) from the smooth data file name.

3. Note that the 9th character of the job name is replaced with l or r.

4. Open parameter file and read parameters.

PROCEDURE XDIRECTION

Currently disabled, this procedure attempts to determine the direction of progression (the direction that the subject walks within the lab). The current program defaults to assuming that the subject walks along the +X axis.

PROCEDURE GET_STATIC

Thigh and shank rotation angles can be corrected internally. The pelvic tilt correction has to be given manually. The correction angles can be given from the terminal or it can be calculated from the static data and the data with medial markers.
PROCEDURE MARKERS
Opens MAR.TXT;1 and gets the marker set for the right side. For the left side, get the marker set from MAL.TXT;1

OPEN SMOOTH DATA FILE
REPEAT the following calculations for all the frames.

READSMO: Read X,Y,Z data of all markers for a frame
REFVECT: Calculate Unit vectors in the ground reference.
PELVANG: From the coordinates of markers 1,2 and 3, calculate the pelvic coordinate unit vectors and using the Euler angle formulae calculate pelvic angles with reference to the ground.
HIPCENTER: Calculate hip center based on empirical relations.
STOREANG: Store the pelvic angles
KNEECENTER: Calculate knee center from the hip center, thigh marker, knee marker and the knee diameter.
ANGLES: Calculate hip angles.
STOREANG: Store hip angles
ANKLECENTER: Calculate ankle center from the knee center, shank marker, ankle marker and the ankle diameter.
ANGLES: Calculate knee angles.
STOREANG: Store knee angles
FOOTANGLES: Calculate ankle angles.
STOREANG: Store ankle angles
CHANGEANG: Change left side angles to take care of the sign.

END
WRITEANG: Write the angles in a file with extension ANR/ANL.

Compilation
To compile and build ACB under RSX-11M use the ACB.TKB command file or the following commands:

pas ACB
 tkb ACB/FP/CP=ACB,[1,1]PASLIB/LB

ACCB
This program calculates the lower limb rotation angles from the smoothed 3-D coordinates of markers.
This program must be run after the smoothing program ASB. If VICON data files are located in V12:[300,100], then GPCB creates a parameter file with extension PAF/PER/PEL in V12:[300,100] and temporary files TEM.TXT;1 & TEM1.TXT;1 in the user directory, all in text format.
The smoothing program (ASB) creates a smoothed data file in real format with extension .SMO in V12:[300,100] and a marker sequence data file MAR.TXT;1 for
the right limb and MAL.TXT;1 for the left limb in text format in the default user directory. Also the PAF, PER, PEL and TEM.TXT files are updated in the smoothing program.

The ACB program creates a file of angles (Real format) with the extension ANG/ANR/ANL in V12:[300,100].

Calculation sequence

PROCEDURE READPARA - Open parameter files
PROCEDURE XDIRECTION - Determine direction of walking (+X axis)
PROCEDURE GET_STATIC - Correct Thigh and shank rotations
PROCEDURE MARKERS - get the marker sets from MAR and MAL.TXT
OPEN SMOOTH DATA FILE and repeat calculations for all the frames.

READSMO - Read X,Y,Z data of all markers for a frame.
REFVECT - Calculate Unit vectors in the ground reference.
PELVANG - Calculate pelvic coordinate unit vectors and angles.
HIPCENTER - Calculate hip center based on empirical relations.
STOREANG - Store the pelvic angles
KNEECENTER - Calculate knee center
ANGLES - Calculate hip angles.
STOREANG - Store hip angles
ANKLECENTER - Calculate ankle center
ANGLES - Calculate knee angles.
STOREANG - Store knee angles
FOOTANGLES - Calculate ankle angles.
STOREANG - Store ankle angles
CHANGEANG - Change left side angles to take care of the sign.
WRITEANG - Write angles in a file with extension ANG/ANR/ANL.

Compilation

To compile and build ACCB under RSX-11M use the ACCB.TKB command file or the following commands:

pas ACCB

tkb ACCB/FP/CP=ACCB,[1,1]PASLIB/LB

ACSB

This program is for calculating the rotation angles of the pelvis, hip and knee using the condyle and malleoli markers. This calculation is two-dimensional. In other words the rotations taking place in the horizontal plane alone is calculated. This is only for the static data.

This program is included in the command file AS.CMD. The program will ask for the job number in which the output is to be saved. If you have combined condyle and
malleoli markers in the static data, then give any other job number other than 1 and make sure that this number does not interfere with others. For example if you have 5 datasets and dataset 1 is static with condyle data, then while running ACSB give 6 as dataset number.

Compilation

To compile and build ACSB under RSX-11M use the ACSB.TKB command file or the following commands:

```
pas ACSB
 tub ACSB/FP/CP=ACSB,[1,1]PASLIB/LB
```

ASB

This program is developed to smooth the raw three-dimensional coordinates obtained from VICON-AMASS. Velocity, stride-length, and direction of progression are also calculated in this program. The parameter file is rewritten with this information.

Basic requirements

This program must follow the gait parameter program GPCB. At least 3 frames of data on both sides of gait cycle are needed. For example, if gait cycle is 20-80, then data is needed from frames 17-83.

Files created

If the VICON data were stored in V12:[300,100], then program-GPCB creates a parameter file with extension PER/PEL in V12:[300,100] and two temporary files, TEM.TXT;1 and TEM1.TXT;1 in the user directory, all in text format. This smoothing program-ASB creates a smoothed data file in real format with extension SMO in V12:[300,100] and a marker sequence data file MAR.TXT;1 for the right side or MAL.TXT;1 for the left side in text format in the user directory. Also the PER/PEL and TEM.TXT files are updated.

Calculation sequence

Follow the program source code for full details. Open TEM.TXT;1 and read the 35-character smooth-data-file name, SNAME. Open BU.TXT;1 and assign the analysis procedure(Either B or U). Open TEM1.TXT;1 and read either l or r depending on the particular limb. Assign TRD filename and PAF(PER/PEL) filename using the smooth-data file name. Depending upon the particular side under consideration, open parameter file and read parameters. Get the first, last and toe off frames of the particular job.

PROCEDURE MARKERS

For the right side, open MAR.TXT;1 and get the marker set. If this file does not exist then get the marker set from the terminal and store them. Similarly for the left side, open MAL.TXT;1 and get the marker set.

PROCEDURE ASMOOTH

Open SMO file for writing and open the TRD file for reading.

Read the first record of the TRD file and get number of markers and the frame number of the first set of data. Read up to four frames ahead of the starting frame of gait cycle.
Read seven frames so that the fourth (middle) frame becomes the starting frame of gait cycle and save them for further calculation. If opposite side ASIS marker is missing, assign the X, Y, and Z coordinates same as that of the other side.

Y-coordinate is moved by a fixed distance.

This approximation is provided to get only the sagittal plane angles in the event of missing ASIS marker. Note that the pelvic obliquity and pelvic rotation are zero under this circumstance.

Repeat the following calculations for Nframes.

1. Smooth the data using a window 0,1,3,4,3,1,0.
2. Save the smoothed data.
3. Get the coordinate of ankle marker at first frame and final frame to calculate stride length. The displacement of ankle marker from first frame to the final frame of gait cycle is considered as stride length.
4. Calculate the instantaneous velocities of sacral stick and ASIS markers and sum them over all frames of gait cycle. Use -1,-3,-3,0,3,3,1 as coefficients for velocity estimation from the raw TRD data. 50 HZ is assumed for this calculation.
5. Calculate the X,Y coordinates of the mid point of ASIS markers. These midpoints define a trajectory in the XY-plane. The direction of progression is calculated by fitting a straight line to these points which minimizes the least square errors.

   The slope of this straight line (B) is calculated. From the slope the direction is determined by taking the arctangent. The angle of progression is positive if the person walks in the +X and +Y direction.

   Move the data from frames 2-7 to frames 1-6.

   Read data from next frame and assign them to 7th frame. Take care of the missing ASIS marker in this frame as explained above.

End;

Calculate average velocity.
Calculate direction of progression.
Return.

Update velocity, Stride_length and direction of progression. Append number of markers and decimal job number to the file TEM.TXT;1 Save the parameters in the file with extension PER/PEL.

**Compilation**

pas ASB

**Task Builder**

tkb ASB/FP/CP=ASB,[1,1]PASLIB/LB (or @ASBT )
ECAL

**Calculation sequence**

a) Get the job name from TEM.TXT;1 and DEV.TXT;1  
b) Open ECHANNEL.TXT;1 and read the EMG channel numbers.  
c) Open .ADC;* file and read the raw EMG data (sampled at 600Hz or 10 analog samples per 3D frame)  
d) Find the maximum and minimum value of Emg data and the range (Max-min) for all 10 channels.  
e) Get the amplitude of CAL signal (in Millivolts) and the identification of electrodes (from A to J) for all 10 channels  
f) Open EGAIN.TXT;1 and reads the gain of all 10 electrodes.  
g) The Range of EMG data in ADC units (10 values) with amplitude of cal signal, and the gain of corresponding electrodes are written in .E05;* file.

Reads: jobname.ADC, TEM.TXT and DEV.TXT  
Uses: ECHANNEL and EGAIN.TXT files  
Creates: jobname.E05

ECAV

This program reads the processed EMG data from .E03;* or .E01;* and averages the data over a specified number of cycles.

Input: .E01;* or .E03;*  
Output: .E04;*  
Intermediate: TEM.TXT;1, .V01;*, .C01;*, .T01;*, .M01;*, .S01;*

**Calculation sequence**

a) Gets the job name from TEM.TXT;1 file and assigns the input EMG file name depending on the smoothness required (.E01;* for less smoothing, .E03;* for well smoothed )  
b) Reads the Gait events from .CAF;1  
c) Calculates Velocity (based on 6m walkway) and save it in .V01;*  
d) Gets any comment to be written on the plot and save it in .C01;*  
e) Gets the SIDE to be analyzed and save them in .T01;*  
f) Gets the Muscle identification numbers and save them in .M01;*  
g) Gets the number of cycles and the cycle numbers to be averaged and save them in .S01;*  
h) Reads the EMG data channel by channel and normalizes every cycle into 64 data points and averages the specified cycles of data. Both mean and SD are calculated at each point. Data from first 3 cycles, mean and Standard deviation (total 5 sets) are saved in .E04;* for final plotting.
ECGAITP

This program reads the gait events from .CAF;1 and calculates gait parameters and writes them in CAF;3. Also this program reads the switch events from .CAF;2 and calculates the ON/OFF points as a percent of gait cycles and writes them in CAF;4.

Input: CAF;1 and CAF;2 files.
Output: CAF;3 and CAF;4 files.
Intermediate: TEM.TXT;1

**Calculation sequence**

a) Gets the job name from TEM.TXT;1
b) For every cycle reads the following 5 points from .CAF;1 FIRST, OPPFOOTOFF, OPPFOOTON, FOOTOFFP, LAST
c) Calculates Gait parameters using the following formulae:
   Sample_rate := 60.0;
   Cycle := Last- First;
   1 Stride_time := Cycle/Sample_rate;
   2 Cadence := 120.0/Stride_time;
   3 Stance := (footoffp - First)/Cycle*100;
   4 Swing := 100-Stance;
   5 Swing_stance := Swing/Stance;
   6 Steptime_right_to_left:= (Oppfooton-First)/Sample_rate;
   7 Steptime_left_to_right:= (Last-Oppfooton) /Sample_rate;
   8 Single_support := (Oppfooton-Oppfootoff) / Cycle *100;
   9 Double_support :=(footoffp-Oppfooton)/Cycle*100
All these 9 parameters are written in .CAF;3
d) Reads ON/OFF points of 4 switches from .CAF;2 Uses the following formulae to find ON/OFF percentages.
   Cycle := Last-First;
   1 Contact_percent := (Contact_frame_number-First)/Cycle*100.0;
   2 Off_percent := ( Off_frame_number-First)/Cycle*100.0;
Writes the results into a file .CAF;4

ECGFF

This program determines

a) FOOT-FLOOR Contact Points (GAIT CYCLES) and
b) On/Off points of four FOOT SWITCHES within each cycle.

Input data: VICON ADC file.
Output: CAF;1 (GAIT CYCLES). CAF;2 (ON/OFF Points of Foot Switches).
Intermediate files: TEM.TXT;1, DEV.TXT;1, CHANNELE.TXT;1, CHANNELE2.TXT;1

Limitations: Up to 20 datasets within a Job, Up to 20 Cycles within a dataset, Upto 3600 frames of data within a dataset (1 minute of data)

**Sequence of Calculation**

1. File name is obtained from the terminal and TEM.TXT;1 is created Directory of datasets is obtained from DEV.TXT;1.
2. Check for the file .CAF;1. If it exists then terminate the execution.
3. If .CAF;1 does not exist then Check for the existence of ADC files.
4. Execute the following steps if at least one ADC file exists for the job.
   a) If a summer is included in the footswitch circuit then Get the Left and Right footswitch Channel numbers and save them in CHANNELE2.TXT;1. Otherwise Get all 4 Channel numbers of Left as well as Right foot-switches and save them in CHANNELE.TXT;1
   b) Read the first record of ADC file (128 integers) Convert them into 256 integer*2 numbers Get the sampling rate and number of channels
   c) Read the data frame by frame. Use the first sample in every frame for further calculation
   d) If the SUMMER is used then the following logic is used to find out ON/OFF points of all four switches. Subtract the baseline(2048) and divide by 128 so that data now varies from 0 to 15.

If the data is ZERO then no switch is ON.
Switch#1 is ON if the data is 8
Switch#2 is ON if the data is 4
Switch#3 is ON if the data is 2
Switch#4 is ON if the data is 1

Other combinations can be easily worked out. For example if the data is 11, then switches 1,3,4 are ON and switch#2 is OFF.

   e) If the data is spiky then up to 5 frames of spikes are removed from the summer data. Now the foot-floor contact ON and OFF points are obtained by scanning the data frame by frame for a change from 0 to a positive number and a change from a positive number to Zero.

   f) Obtain individual gait events (the gait cycle is checked for a minimum length of 30 frames) and save them in .CAF;1. Obtain switch contact patterns and save them in .CAF;2

---

**ECSE**

This program reads the emg data from .ADC;* and rectifies, smoothes, and integrates the data. Regardless of different sampling rate/frame, the output will be always one sample/frame(60HZ).
Input: .ADC;*
Output: .E01;*
Intermediate: TEM.TXT;1, DEV.TXT;1, ECHANNEL.TXT;1
Limitations: Only 10 channels of EMG is processed.

**Calculation sequence**

a) Gets the jobname from TEM.TXT;1
b) Gets the Job location from DEV.TXT;1

Calculation of the EMG channel numbers from ECHANNEL.TXT;1

b) If the data is unrectified, then the baseline is assumed as 2048. 2 seconds of data (120 frames) is averaged to get the offset from baseline for each channel. The baseline is corrected for this offset.

c) Data is rectified about the corrected baseline.

d) A 32ms moving cosine window smoothing is applied to the rectified data. Characteristic function of the moving Window is \( \frac{1 - \cos(2\pi X)}{2.0} \)

E) Smoothed data is integrated and averaged at each frame. The final output will be in 60HZ (one sample/frame) and it is saved in .E01;*

---

**ECSM**

This program reads the smoothed EMG data from .E01;* and further smoothes it by applying a 5 point Hanning window.

Input: .E01;*
Output: .E03;*
Intermediate: TEM.TXT;1.

**Calculation sequence**

a) Gets the jobname from TEM.TXT;1
b) Opens .E01;* file and reads the EMG data (at 60HZ)
c) First 2 frames and the last 2 frames of data are not processed.

d) Rest of the data will be smoothed using the coefficients 1,3,4,3,1.

e) Output will be written in .E03;* file.

---

**EMG**

Analyze and plot Electromyographic GAIT-data obtained on 10 muscles

What is done:

Gait cycles correspond to left and right sides are obtained from footswitch information.

ON/OFF points of 4 footswitches placed at heel, fifth, first and toe are determined.

Gait parameters are then calculated from these gait events.

EMG data are read from .ADC files.

First the baselines in the EMG data are obtained by averaging 2 seconds of EMG data.

Then the data are rectified about this baseline.

A 32 ms moving cosine window is applied to the data.

The data are integrated and averaged within a frame.
Further the data from the channels are split into number of gait cycles, converted to equal number of points within each gait cycle and both mean and SD are calculated at every frame.

If a calibration dataset is collected then the scale factor is obtained from the cal set. Finally the data are plotted either normalized or in microvolts using calibration data.

**HOW TO USE THE SOFTWARE**

**Step 1**
Log into the specified directory where the command files are saved.

**Step 2:**
Type the command @E (which executes the following six programs in sequence) to analyse and plot EMG data.

RUN [RAKESH]ECGFF
RUN [RAKESH]ECGAITP
RUN [RAKESH]ECSE
RUN [RAKESH]ECSM
RUN [RAKESH]ECAV
RUN [RAKESH]ECFPLOT

The detailed explanation of the functions of these programs are saved in the corresponding text files. For example TYPE ECAV.TXT to see what is done by the program ECAV.

**Step 3:**
Use the command @EPL (which runs the following two programs) to plot EMG data which has already been analyzed. This command is useful if you have to replot the data.

RUN [RAKESH]TEMB
RUN [RAKESH]ECFPLOT

**Step 4:**
If you want to plot the raw EMG data as collected for a particular gait cycle then use the command @ERAW which reads as follows.

RUN [RAKESH]TEMB
RUN [RAKESH]ECFRPLOT

**Step 5.**
To analyze the calibration data(if any) use the command @ECAL which runs the following 2 programs.

RUN [RAKESH]TEMB
RUN [RAKESH]ECAL
Step 6.

If you want to get a printout of gait parameters then use the following two programs which are executed by the command @EGP.

RUN [RAKESH]TEMB
RUN [RAKESH]EGP

Step 7.

There are two more programs available to plot 6 channels of EMG-data either in the processed form (program [RAKESH]ECFFPLOT) or in the RAW form (program [RAKESH]ECFXPLOT). These plots can be combined with motion data.

In summary, there are 12 programs available in the directory [RAKESH] for Emg analysis.

ECGFF - To find Gait events and footswitch ON/OFF points.
ECGAITP - To calculate gait parameters.
ECSE - To rectify and smooth emg data.
ECSM - To add another smoothing.
ECAV - To split and average EMG data over multiple cycles.
ECFPLOT - To plot all 10 processed emg data.
ECFFPLOT - To plot only 6 processed emg data.
ECFRPLOT - To plot all 10 raw emg data from a specified cycle.
ECFXPLOT - To plot only 6 raw emg data from a specified cycle.
ECAL - To calculate calibration scale.
ECP - To print gait parameters.
TEMB - To create a temporary file TEM.TXT;1 with the job name.

FPCB

Force plate data analysis program -

Files Used:

Following text files are created by the program during the first run. Subsequent runs will open these files and read the contents.

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Name</th>
<th>Location</th>
<th>Contents</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DEV.Txt;1</td>
<td>User directory.</td>
<td>Directory of- data files</td>
<td>V12:[300,100]</td>
</tr>
<tr>
<td>2</td>
<td>TEM.TXT;1</td>
<td>User directory.</td>
<td>Current filename</td>
<td>V12:[300,100];C.SMO;1</td>
</tr>
<tr>
<td>3</td>
<td>TEM1.TXT;1</td>
<td>User directory.</td>
<td>Side(Left/Right)</td>
<td>R</td>
</tr>
<tr>
<td>4</td>
<td>HOS.TXT;1</td>
<td>User directory.</td>
<td>Title for plots</td>
<td>HELEN HAYES HOSPITAL - GAIT ANALYSIS</td>
</tr>
<tr>
<td>5</td>
<td>TER.TXT;1</td>
<td>User directory.</td>
<td>Terminal type</td>
<td>4014 or 4114</td>
</tr>
<tr>
<td>6</td>
<td>CP.TXT;1</td>
<td>User directory</td>
<td>Yes/No for Center of pressure plots</td>
<td>N</td>
</tr>
</tbody>
</table>
7 *PER;1 Dir. specified- Gait Parameters Type one to see-the
*PEL;1 in DEV.TXT;1 contents

8 *FPR;* Dir. specified- Forces and moments in
*FPL;* in DEV.TXT;1 real format Type @FPRINT to see
the contents.

SOURCE CODES : FPCB.PAS, FPSUBCB.PAS, G.PAS

COMPILATION : PAS FPCB, PAS FPSUBCB

TASK BUILDER : TKB @FPCBT

COMMAND FILE : FPCBT contains the following.

```
FPCB/FP/CP=FPCB, FPSUBCB,[1,1]PASLIB/LB
/
UNITS=20
//
RUNNING : RUN FPCB ( @F )
```

This program plots the force data immediately after calculation. This must be run on
a graphic terminal (Either 4010 series or 4110 series). No colors at this time. The
current data can be plotted against another reference data.

Input N for reference data if the normal data base is needed.
Input S for reference data if you don’t need this extra plot.
Input Z and then another run number(ex 3 or 14) if you need to see both
together.
Input D for different job and then answer the subsequent question with the
job name and dataset number.

Last 10 frames from the specified gait cycle for a particular dataset are used to
calculate the zero offset for the forces. For example if the gait cycle of a particular
dataset is from 20 to 80, then the average data from frames 71 to 80 is used as zero
offset for that dataset.

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**FPC1B**

This is a force calculation program. This is separated from the program FPCB. This
program is useful when the number of frames in a particular dataset exceeds 120.
Again this program is limited to 200 frames only. The other comments written in
FPCB.txt are valid for this program also.

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**FPCC1B**

This is a force calculation program. This is separated from the program FPCCB and
it does only the calculation. The other comments written in FPCB.txt are valid for
this program also. NO PLOTTING IS DONE.
FPCC2B

This is a force calculation program. This is separated from the program FPCCB and it does only the calculation. The other comments written in FPCCB.txt are valid for this program also. NO PLOTTING IS DONE. This program creates a file .FPM in which the center of pressure is written with respect to the VICON zero instead of force plate zero. This is done to help plotting stick diagram.

FPC

Convert ADC data into forces.
Input: ADC files
Output: .FPM;*, .FPP;*, FCHANNEL.txt;1, FCORR.txt;1,FMOD.txt;1, PARA.txt;1
Intermediate: TEM.txt;1, DEV.txt;1

Calculation sequence
Get the job name from TEM.TXT;1 and directory from DEV.TXT;1
Get the channel numbers of both AMTI force plates from FCHANNEL.txt;1
Get the 6*6 correction matrix from FCORR.txt;1
Get the index for relative force plate-orientation from FMOD.txt;1
Get the X,Y,Z coordinates of force plates, size of force plates, and number of frames for baseline calculation from FPARA.txt;1
Repeat the following calculations for all the datasets:
  a) Get the baseline data from the specified frames.
  b) Read the ADC data sample by sample and subtract the baseline.
  c) Calculate forces using the correction matrix.
  d) Change the sign of forces depending on force plate orientation.
  e) Write the forces obtained from the first sample in every frame into the file .FPM
End

GPCB

GPCB is a program for Calculating Gait events and Gait-parameters from the ADC data
A temporary file (TEM.TXT;1) is created containing the name of the VICON job in the default user file directory for the first run. The information in this file is subsequently used for the rest of the runs. Type the file TEM.TXT;1 to see the contents of the temporary text file. This temporary file is essential for the angle calculation programs, plotting programs, force calculations and moment calculations.
The location of the data files (ie, the directory) is saved in the file DEV.TXT;1. If you want to change the data file directory, then simply delete the file DEV.TXT;1 and run the GPCB program to create a new file called DEV.TXT;1 that will contain the name of new directory. Type the file DEV.TXT;1 to see the name of your current directory.
The analysis is done for one limb at a time. The particular limb under consideration either l (for left) or r (for right). This information is saved in the file TEM1.TXT;1 in text format for use by other programs. Type the file TEM1.TXT;1 to see the current side under analysis.

A parameter file (again in text format) is created in the specified data directory for each job that is analyzed. These parameter files will have the same name as the job and one of two file types (.PER and .PEL) so that the left and right side data can be saved separately e.g. VI2:[300,100]JOHNDOE01.PER;1. Here JOHNDOE01 is the 9 character job name and VI2:[300,100] is the specified directory. The file extension may be either PEL or PER depending on the side (left or right) being analyzed. This is a text file so that you may type it to the screen to see the contents of parameter file:

> TYPE VI2:[300,100]JOHNDOE01.PER;1

Currently the program handles 20 runs in any particular job. If you need more data runs then you must split the job into two or more separate job during data collection.

The contents of the PER/PEL parameter files are listed below:

1. 9 Character patient identification (Used in plotting program)
2. P for Patient, N for Normal subject (Used in plotting only)
3. Analysis limb - l for Left side data, r for Right side data.
4. Average Pelvic tilt (Normally 18 degrees). This is used for hip center calculation. Run the static job and get the average pelvic tilt then run GPCB and edit the parameter file and change the pelvic tilt from 18 to the tilt you obtained from static run.
5. Subject Leg length in centimeters.
6. Subject Knee width in centimeters.
7. Subject Ankle width in centimeters.
8. Marker radius in centimeters.
9. Number of runs of data (Maximum of 20 runs per job)

Following line 9 (number of runs) there will be 3 times the number of runs plus 3 more lines will appear as described below.

If N is the number of runs in a job then there will be:

N lines containing First, Last and footoff frames of the runs in sequence.
N lines containing the First, Last, footoff, Op.footoff and Op.foot contact for the runs in sequence.
N more lines with the following information in sequence in each line.

   Cadence,
   Stride time,
   Steptime R/L,
   Steptime L/R,
   Swing,
   Stance,
   Swing/stance,
   Single limb support,
Double support,
Velocity,
Stride length
Direction of progression

(Formulae used to calculate these parameters are listed in the next section)

One line with mean and
One line with S.D. of all these parameters for that job.

The last line has the step length and step width as first two parameters which are to be included manually during editing the parameter file. The third parameter in this line is the body weight in pounds. The rest of the information in this line is reserved for future use (currently zeros).

The left and right footswitch analog channel numbers are written in a file called CHANNEL.TXT;1. You may type the file CHANNEL.TXT;1 to the screen to find out the current channel numbers. Delete this file and rerun the program if the channels are changed. GPCB will ask for channel numbers and recreate this file.

**Calculation of Gait events**

ADC data from the Left and Right footswitch channels are read frame by frame. The following analysis is done on both left and right channels separately.

The difference in ADC level from the current frame to the previous frame is calculated. If this difference is positive then we assume that switch is turning ON or closing. Conversely, the difference is negative if the switch is turning OFF or opening. The absolute magnitude of this difference indicates whether it is heel, fifth, first or toe switch or a combination of these switches.

If $50 \leq \text{Absolute difference} < 150$ then First is closed.
If $150 \leq \text{Absolute difference} < 250$ then Heel is closed.
If $250 \leq \text{Absolute difference} < 350$ then First & Heel are closed.
If $350 \leq \text{Absolute difference} < 450$ then Fifth is closed.
If $450 \leq \text{Absolute difference} < 550$ then First & Fifth are closed.
If $550 \leq \text{Absolute difference} < 650$ then Heel & Fifth are closed.
If $650 \leq \text{Absolute difference} < 750$ then First, Heel & Fifth are closed.
If $750 \leq \text{Absolute difference} < 850$ then Toe is closed.
If $850 \leq \text{Absolute difference} < 950$ then First & Toe are closed.
If $950 \leq \text{Absolute difference} < 1050$ then Heel & Toe are closed.
If $1050 \leq \text{Absolute difference} < 1150$ then First, Heel & Toe are closed.
If $1150 \leq \text{Absolute difference} < 1250$ then Fifth & Toe are closed.
If $1250 \leq \text{Absolute difference} < 1350$ then First, Fifth & Toe are closed.
If $1350 \leq \text{Absolute difference} < 1450$ then Heel, Fifth & Toe are closed.
If $1450 \leq \text{Absolute difference} < 1550$ then First, Heel, Fifth & Toe are closed.
The results from the above analysis are not used in the current version of the software to calculate foot-ground contact patterns. A different logic to identify only the foot contact and foot off points is included which is a simpler and reliable one.

Once the foot contact pattern is established, the required events for the first gait cycle are picked up. The events for the second gait cycle are also printed for information. Since the smoothing program requires 3 extra frames at the beginning, the program picks the second gait cycle automatically if the starting frame number of the first cycle is less than 4.

Definitions of gait parameters

The conventions used for calculating gait cycle parameters are:

- FIRST : Sample number of the First foot strike
- LAST : Sample number of the second foot strike (opposite foot)
- FOOTOFF : Sample number of First Foot off
- OFO : Sample number of Opposite Foot off
- OFC : Sample number of Opposite Foot contact
- RATE : Sample frequency (typically 50 or 60 sample/sec).

1. CADENCE (Steps/minute) = 120*RATE/(LAST - FIRST)
2. STRIDE TIME (Seconds) = (LAST - FIRST)/RATE
3. STEPTIME R/L (Seconds) = (OFC - FIRST)/RATE { For RIGHT side data }
   STEPTIME R/L (Seconds) = (LAST - OFC)/RATE { For LEFT side data }
4. STEPTIME L/R (Seconds) = (OF0 - FIRST)/RATE { For RIGHT side data }
   STEPTIME L/R (Seconds) = (LAST - OFC)/RATE { For LEFT side data }
5. SWING (% Gait Cycle) = (LAST - FOOTOFF)/(LAST - FIRST) * 100
6. STANCE (% Gait Cycle) = 100 - SWING
7. SWING/STANCE (Percent) = SWING / STANCE
8. SINGLE SUPPORT (% Gait Cycle) = (OFC - OFO)/(LAST-FIRST)*100
9. DOUBLE SUPPORT (% Gait Cycle) = ((OFO - FIRST)+(FOOTOFF-OFC))/(LAST-FIRST)*100
10. VELOCITY (Meters/Second) = Average velocity of Pelvic markers (ASIS and Stick)
11. STRIDE LENGTH (Meters) = Ankle marker displacement during the cycle.
12. DIRECTION of PROGRESSION (Degrees) = Direction of the mid point of ASIS markers w/ respect to X axis.

Calculation sequences for GPCB

1. Open the text file TEM.TXT;1 and read the current VICON Job name.
2. Give the user the chance to chose a different Job name.
3. Rewrite the file TEM.TXT;1 with the selected Job name.
4. Open the text file DEV.TXT;1 and read current directory name.
5. Ask the user which side (left or right) is to be analyzed and save this information in the text file TEM1.TXT;1

7. Create the Parameter file name, check for its existence in the directory specified by DEV.TXT;1 and read the contents of the file if it exists. If the file does exist then offer the user the opportunity to modify the existing parameters.

8. If there is no parameter file then:

   8.1 Ask the user for the following details:
   Patient name
   Leg_length
   Knee, and Ankle Widths
   Body weight
   Number of runs (Nruns)

   8.2 Test for an .ADC file and attempt to determine the Gait Parameters from the footswitch data. If the .ADC file cannot provide the Gait Parameters then ask the user for the following details:
   FIRST First foot strike frame number
   LAST Opposite foot strike frame number
   FOOTOFF First foot off frame number
   OFO Opposite foot off frame number
   OFC Opposite foot contact frame number

**RADCB**

This program is written to read VICON ADC files. Current program reads two channels and writes them. Job name and dataset number are given in the beginning.

Then the operator can choose two channels. You can select channel 15 and 16 to read the foot switch analog data. The output will contain both raw data and the difference in data compared to the previous frame.

**TEMB**

This is a small temporary program, written to assist the angle plotting program APB. This is included in the command @APLOT. This program creates 3 temporary files TEM.TXT;1, TEM1.TXT;1 and BU.TXT;1 which are read by APB.
Plotting Programs

AP3B

Angle plotting program for bilateral gait analysis

This program plots the angle data file created by ACCB and should be run after
ACCB has been executed to create the data file.

CALCULATION SEQUENCE

The file REF.TXT;1 is open and a character (either S or G) is read from the file - S
plots relative angles, G plots absolute angles.

Based on the type of terminal, the program assigns an index using the variable ITER
as follows:

1 for 4114, 2 for 4014, 3 for RETRographics, 4 for 4012, and 5 for EM4105
graphics. Line style routines and character size procedures are called based on this
index ITER as explained below:

<table>
<thead>
<tr>
<th>Terminal</th>
<th>ITER</th>
<th>Line style procedure</th>
<th>Character size procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>4114</td>
<td>1</td>
<td>LINE_STYLE</td>
<td>ALPHA_SIZE</td>
</tr>
<tr>
<td>4014</td>
<td>2</td>
<td>L4014_STYLE</td>
<td>ALPHA_SIZE4014</td>
</tr>
<tr>
<td>RETRO</td>
<td>3</td>
<td>LRETR_STYLE</td>
<td>default sizes</td>
</tr>
<tr>
<td>4012</td>
<td>4</td>
<td>only solid lines</td>
<td>default sizes</td>
</tr>
<tr>
<td>IBMP</td>
<td>5</td>
<td>LINE_STYLE</td>
<td>ALPHA_SIZE</td>
</tr>
</tbody>
</table>

Since a lot of information appears on the same plot, the program will print the gait
parameters only when requested unless you are using a 4114 which always displays
the gait parameters.

Next, the program asks for the title which is going to appear on the top of joint angle
plot. This title (maximum of 60 Characters) is saved in a file HOS2.TXT;1 - delete
this file to change the title.

Open the file TEM.TXT and get the job name and decimal run number. Note that
this temporary file is created by the program GPCB and subsequently appended by
the program ASB.

Open the file BU.TXT;1 and read either B (Bilateral analysis) or U (Unilateral
analysis).

Open the file TEM1.TXT;1 and get the side (L = left / R = right) under
consideration.
Assign the parameter file (PAF/PER/PEL) and read parameters of the current job (specified in the file TEM.TXT;1).

This program has the provision of plotting the current data against two other datasets for easy comparison purposes. The second/third datasets can be located anywhere in the system:

S - Means Same data - only one plot appears on the screen.

N - Normal data - during the first run, the name of normal data file must be entered. This name is stored in a file called AFILE.TXT;1 in the user directory. Subsequent runs will read the normal datafile name from this textfile and open the corresponding file for plotting.

O - Other limb data - In bilateral analysis the joint angle date for left and right limbs is stored separately - use this option to compare both sides for symmetry.

D - Different data - The name of the datafile in the following format must be entered:
DL1:[300,100]XXXXXXXXX.ANG;12

The data file and the corresponding PAF file must be located in the same directory.

Z - or any other character - if multiple runs are taken for the same job then one job can be plotted against another by just giving Z and then giving the dataset number. This can be a static configuration. Make sure that the joint angles for the other runs had been calculated before attempting to plot against the current job.

If the specified dataset does not exist the program ignores the second job and plots only the current dataset under consideration.

The parameters of the second/third job are read from the corresponding parameter file. The number of frames are scaled to 100% of the cycle length for plotting purposes.

The joint angles are read into an array ANG[600,3,4] - maximum number of frames = 600. Angles are classified into 3 columns and 4 rows as they appear in the final plot. For example, the angle appears in the second column and third row is the KNEE VARUS-VALGUS ANGLE. Two indices I and J are used to identify the particular angle. I refers the column and J refers the row in which the particular angle is plotted. I=2 and J=3 for Knee varus-valgus. These two indices are used in a loop to plot all the angles.

Xstart and Ystart define the lower left corner of a particular plot and they are calculated based on I and J. All other locations of the plot are related to Xstart and Ystart.

The joint angles are calculated either relative to ground reference or relative to the proximal segment. To differentiate between these two types, the angle calculation program writes either S (segment) or G (ground) in a text file REF.TXT;1 in the user directory. This REF.TXT;1 is read by the plotting program AP3B and depending on the type of angles, the title is written (Either Relative angles or absolute angles).

Predefined scales for the vertical axes of the plots were assumed based on our experience. Even if the data exceeds the plot limits, the program will plot them, but the scales must be extrapolated under these circumstances. During the very first run, a question will appear asking for the multiplication factors for the plots. Input 1 for all 12 questions and see the plot. The program will create a text file SCALE.TXT;1 with these scales in the user directory. Type SCALE.TXT;1 to see the current scales.

A limited option is given on the multiplication factor (1 or 1.5 or 2 or 3). You can selectively change the scales of particular plots. For example if you want to change the scale of the hip rotation angle to vary from -60 to +60 degrees (existing scale is
from -30 to +30 degrees) then input 2 for the question on 2nd row and 3rd column. The rest of the factors would be 1.0.

**APB**

**Angle plotting for bilateral gait analysis**

This program plots the angle data written by the program ACB. This program is designed to follow the program ACB. In other words it is necessary to run this program immediately after running ACB. However if you need to plot the angles which were calculated earlier, then, RUN [1,15]TEMB to create a temporary file and then run APB to plot the data.

**Terminal Emulation**

The type of terminal must be specified in the first run. The Helen Hayes Software supports a limited number of graphics terminals – currently the Tektronics 4114, 4014, 4012 are supported together with the RetroGraphics VT100 along with any terminal that supports an emulation of these terminals. The terminal type is stored in a file TER.TXT;1 and this file is read by the program during the subsequent runs.

If the file TER.TXT;1 is missing in your directory, you will be asked to enter the terminal type and it will be stored. If you need to change the terminal type at any point of time, then delete TER.TXT;1 in your directory and rerun this program.

TYPE TER.TXT;1 to see the current terminal selection.

Based on the type of terminal, program assigns an index using the variable ITER as follows

ITER = 1 for TEK 4114
ITER = 2 for TEK 4014
ITER = 3 for TEK RetroGraphics
ITER = 4 for TEK 4012
ITER = 5 for TEK for future use

Proper Line style routines and character size procedures are called based on this index ITER as explained below.

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<td>ALPHA_SIZE4014</td>
</tr>
<tr>
<td>RETRO</td>
<td>3</td>
<td>LRETR_STYLE</td>
<td>default sizes</td>
</tr>
<tr>
<td>4012</td>
<td>4</td>
<td>only solid lines</td>
<td>default sizes</td>
</tr>
</tbody>
</table>

Since a lot of information appears on the same plot, the program will print the gait parameters only if it is asked for. A question will appear on the terminal asking for this choice. (This question will not appear on 4114 and the parameters are printed all the time).
Report Title

Next, the program asks for the title, which is going to appear on the top of joint angle plot. This title (with a maximum of 60 Characters) is saved in a file HOS2.TXT;1.

At any point of time, if you decide to change the title, simply delete HOS2.TXT;1 in your directory and rerun this program to recreate this file. TYPE HOS2.TXT;1 to see the current title.

Plotting Options

Open the file TEM.TXT and get the job name and decimal run number. Note that this temporary file is created by the program GPCB and subsequently appended by the program ASB.

Open the file TEM1.TXT;1 and get the side (Either L for left or R for right) under consideration. Again note that TEM1.TXT;1 is created by the program GPCB.

Assign the parameter file and read parameters of the current job which is specified in the file TEM.TXT;1

This program has the provision of plotting the current data against another dataset for easy comparison purposes. The second dataset can be located anywhere in the system. To reduce the number of characters to be typed by the operator on the terminal, the following simplified notation is used to specify the second data set.

S - Means same data (only one plot appears on the screen)

N - Normal data (During the very first run, the name of normal data file must be typed. This name is stored in a file called AFILE.TXT;1 in the user directory. Subsequent runs will read the normal data file name from this text file and open the corresponding file for plotting).

O - Other limb data (In bilateral analysis the joint angle data for left and right limbs are stored separately. To compare both sides for symmetry, this provision is used)

D - Different data (the name of the data file in the following format must be given). Example DL1:[300,100]XXXXXXXXR.ANG;12 the data file and the corresponding PAF file must be located in the same directory.)

Z any other character (If multiple runs are taken for the same job then one job can be plotted against other by just giving Z and then giving the dataset number. This can be a static configuration. But please make sure that the joint angles for the other runs had been calculated before attempting to plot against the current job.)

Another question is 'What happens if the specified dataset does not exist'. Under such condition, the program ignores the second job and plots only the current dataset under consideration.

Calculation sequence

The parameters of the second job are read from the corresponding parameter file. The number of frames is scaled to 100% of the cycle length for plotting purposes.

The joint angles are read into an array ANG[200,3,4]. Here, maximum number of frames = 200. Angles are classified into 3 columns and 4 rows as they appear in the final plot. For example, the angle appears in the second column and third row is the KNEE VARUS-VALGUS ANGLE. Two indices I and J are used to identify the particular angle. I refers the column and J refers the row in which the particular angle is plotted. I=2 and J=3 for Knee varus-valgus. These two indices are used in a loop to
plot all the angles. Xstart and Ystart define the lower left corner of a particular plot and they are calculated based on I and J.

All other locations of the plot are related to Xstart and Ystart. Please refer to the picture attached with this plot for the X,Y locations of various corners and the sizes of the plot.

The joint angles are calculated either relative to ground-reference or relative to the proximal segment. To differentiate between these two types, the angle calculation program writes either S (for segment) or G (for ground) in a text file REF.TXT;1 in the user directory. This REF.TXT;1 is read by the plotting program APB and depending on the type of angles, the title is written (Either Relative angles or absolute angles).

Pre-defined scales for the vertical axes of the plots were assumed based on our experience. Even if the data exceeds the plot limits, the program will plot them, but the scales must be extrapolated under these circumstances. During the very first run, a question will appear asking for the multiplication factors for the plots. Input 1 for all 12 questions and see the plot. Program will create a text file SCALE.TXT;1 in the user directory. Type SCALE.TXT;1 to see the current scales.

If you feel that a change is necessary on the vertical scales, then DELETE SCALE.TXT;1 and rerun the program APB. A limited option is given on the multiplication factor (1 or 1.5 or 2 or 3). You can selectively change the scales of particular plots. For example if you want to change the scale of hip rotation angle to vary from -60 to +60 degrees (existing scale is from -30 to +30 degrees) then input 2 for the question on 2nd row and 3rd column. Rest of the factors = 1.0.

**APBJ**

This program is a modified version of AP3B and the comments for that program are valid for this program also.

The major changes are listed below:
1. This program plots only two sets of angles at a time on the screen.
2. The second set is always normal data (fixed in the program).
3. Instead of gait parameters (as plotted by AP3B), Patient information will be printed to handover to the physicians Patient Name, Hospital ID, age, and date of evaluation.

This program is run from the ANGLE command file.

**APGB**

This program plots one angle at a time on the screen. The comments written for the program APB are valid for this program also. (Type APB.TXT to see those comments).

One extra question has to be answered while running this program. That is the identification of the plot. You have to give the row and column number of the particular angle as it appears on the overall plot. For example
- row 1 column 1 is pelvic tilt
- row 2 column 3 is hip rotation
- row 4 column 3 is foot rotation ....
ECFPLOT and ECFFPLOT

The ECFFPLOT program is a modified version of ECFPLOT. This can plot only 6 muscles and the plot can be combined with joint angles, stick diagram, forces, moment, and power plots. The rest of comments written for ECFPLOT are valid for this program also and they are repeated below.

The ECFPLOT program plots the processed EMG data from .E04;* with either gait parameters averaged over specified number of cycles or Patient information.

Input: .E04;*

Intermediate: HOS3.TXT;1, NORM.TXT;1, TEM.TXT;1, CAF;3, CAF;4,.S01;*, .T01;*, .M01;*, .V01;*, .C01;*, P01;1, .E05;* ESCALE.TXT;1,

Calculation sequence

1. Gets the TITLE of PLOT from HOS3.TXT;1. If HOS3.TXT;1 does not exist then gets the title from operator and save it in HOS3.txt;1.
2. Opens NORM.TXT;1 and reads the NORMAL EMG ON/OFF data.
3. Gets the job name from TEM.TXT;1 Assigns the input emg file name as .E04;*.
4. Gets the number of cycles and the cycle numbers to be averaged from .S01;*
5. Opens the .CAF;4 file and averages the ON/OFF points from individual switches for the cycles specified. Opens the .CAF;3 file and averages the gait parameters for the cycles specified.
6. Opens .M01;* and T01;* and gets the muscle identification.
7. Opens .E04;* and gets the 64 point mean and SD of EMG data.
8. If you ask for normalized plot then another reference data file is open and a set of reference data is read.
9. Gets the Velocity (based on 6m walkway) from the file .V01;*
10. Gets the comment to be written on the plot from the file .C01;*
11. Opens .E05;* file and gets the calibration data.
12. Opens ESCALE.TXT;1 and gets the Y-AXIS SCALING FACTOR.
13. Opens TER.TXT;1 and gets the terminal type and then plots the data on the screen.

ECFRPLOT

This program plots the raw EMG data from .ADC;* with either gait parameters averaged over specified number of cycles or Patient information.

Input: .ADC;*

Intermediate: HOS3.TXT;1, NORM.TXT;1, TEM.TXT;1, CAF;3, CAF;4,.S01;*, .T01;*, .M01;*, .V01;*, .C01;*, P01;1, .E05;* ESCALE.TXT;1,

Calculation sequence

1. Gets the TITLE of PLOT from HOS3.TXT;1. If HOS3.TXT;1 does not exist then gets the title from operator and save it in HOS3.txt;1.
2. Opens NORM.TXT;1 and reads the NORMAL EMG ON/OFF data.
3. Gets the job name from TEM.TXT;1 Assigns the input emg file name as .ADC;*.
4. Gets the number of cycles and the cycle numbers to be averaged from .S01;*. Only one cycle can be plotted at a time. This operator can select any cycle.
5. Opens the .CAF;4 file and averages the ON/OFF points from individual switches for the cycles specified. Opens the .CAF;3 file and averages the gait parameters for the cycles specified.
6. Opens .M01;* and T01;* and gets the muscle identification.
7. Opens .ADC;* and gets the raw EMG data. The operator can ask for rectified plot if necessary.
8. Gets the Velocity (based on 6m walkway) from the file .V01;*
9. Gets the comment to be written on the plot from the file .C01;*
10. Opens .E05;* file and gets the calibration data.
11. Opens ESCALE.TXT;1 and gets the Y-AXIS SCALING FACTOR.
12. Opens TER.TXT;1 and gets the terminal type and plots the data on the screen.

ECFXPLOT

This program is a modified version of ECFRPLOT. This can plot only 6 muscles and the plot can be combined with Joint angles, stick diagram, forces, moment, and power plots. The rest of comments written for ECFRPLOT are valid for this program also and they are repeated below.

ECFRPLOT

This program plots the raw EMG data from .ADC;* with either gait parameters averaged over specified number of cycles or Patient information.

Input: .ADC;*

Intermediate: HOS3.TXT;1, NORM.TXT;1, TEM.TXT;1, CAF;3, CAF;4, .S01;*, .T01;*, .M01;*, .V01;*, .C01;*, P01;1, .E05;*, ESCALE.TXT;1,

Calculation sequence

a) Gets the TITLE of PLOT from HOS3.TXT;1. If HOS3.TXT;1 does not exist then gets the title from operator and save it in HOS3.txt;1.

b) Opens NORM.TXT;1 and reads the NORMAL EMG ON/OFF data.

c) Gets the job name from TEM.TXT;1 Assigns the input emg file name as .ADC;*.

d) Gets the number of cycles and the cycle numbers to be averaged from .S01;*. Only one cycle can be plotted at a time. This operator can select any cycle.

e) Opens the .CAF;4 file and averages the ON/OFF points from individual switches for the cycles specified. Opens the .CAF;3 file and averages the gait parameters for the cycles specified.
f) Opens .M01;* and T01;* and gets the muscle identification.
g) Opens .ADC;* and gets the raw EMG data. The operator can ask for rectified plot if necessary.
h) Gets the Velocity (based on 6m walkway) from the file .V01;*
i) Gets the comment to be written on the plot from the file .C01;*
j) Opens .E05;* file and gets the calibration data.
k) Opens ESCALE.TXT;1 and gets the Y-AXIS SCALING FACTOR.
l) Opens TER.TXT;1 and gets the terminal type and plots the data on the screen.

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**FPCPLOTB**

This is a force plotting program. This is attached as a subprogram in FPCB. The comments on FPCB are valid for this program also. This can be used separately for the existing force data files. This program will plot the force data available in the files FPR/FPL. It is important to note that this will not look for VICON FPD data file.

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**FPC3PLOTB**

This is a force plotting program. This is attached as a subprogram in FPCB. The comments on FPCB are valid for this program also. This can be used separately for the existing force data files. This program will plot three force data sets available in the files FPR/FPL or FPX. It is important to note that this will not look for VICON FPD data file.

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**FPC3PLOTB**

This is a force plotting program. This is attached as a subprogram in FPCCB. The comments on FPCCB are valid for this program also. This can be used separately for the existing force data files. This program will plot three force data sets available in the files FPR/FPL or FPX. It is important to note that this will not look for VICON FPD data file.

**THIS PROGRAM IS INCLUDED IN THE COMMAND FILE FPLOT.COM**

---

**FPCPLOTJ**

This is a force plotting program. This is attached as a subprogram in FPCCB. The comments on FPCCB are valid for this program also. This can be used separately for the existing force data files. This program will always plot force data available in the files FPR/FPL or FPX against NORMAL data.

Patient information (Name, age, ID, Date of eval) are added to the plot.

**THIS PROGRAM IS INCLUDED IN THE COMMAND FILE FORCE.COM**
**FPCXPLTB**

This is a force plotting program. The comments on FPC3PLOTB are valid for this program also. This can be used separately for the existing force data files. This program will plot only the three forces available in the files FPR/FPL or FPX in a format suitable to combine with EMGs, angle etc.

**PANGLEB**

Objective : Print angle data (Bilateral).

Requirements:

Create the angle file with extension ANR/ANL (relative angles) or AAR/AAL (absolute angles) by running the Angle calculation program. During Unilateral analysis ANG and AAG are created. Program PANGLEB will look for these angle files only.

Usage:

Run PANGLEB or @APRINT

Input:

1. Device name - Example DL1
2. Job name - Between 1 to 9 characters
3. Reference frame - S for angles relative to proximal segment. G for angles relative to ground reference.
4. Number of datasets - Upto 8 sets can be printed at a time.
5. Dataset numbers - Example 2 4 17
6. Side (Left/Right) - either L or R arranged in sequence with a space in between them. For example, for the jobs mentioned above (2 4 17), if we need left side data for 2, 4 and right side data for 17, then the input to this question will be L L R
7. If interpolation is needed then answer Y to the next question and then input the number of points.
8. A code is assigned from 0 to 12 for different parameters
   0 for complete data
   1 for Pelvic tilt
   2 for Hip flexion/extension
   3 for Knee f/e
   4 for Ankle f/e
   5 for Pelvic obliquity
   6 for Hip ad/abduction
   7 for Knee ad/abduction
   8 NOT USED
   9 for Pelvic rotation
   10 for Hip rotation
11 for knee rotation
12 for Foot rotation

Flexibilities:
Data can be in any user directory. Data can be compressed or expanded to any number of points between 20 & 200. Generally 64 points are suggested.

Compilation
PAS PANGLEB

Task builder
@PANGLEBT
PFORCEB

Print force data (Bilateral).

Requirements:
Create the force file with extension FPX, FPR or FPL by running the Force Analysis Program. PFORCEB will look for the files with extension FPX/FPR/FPL.

Usage:
Run PFORCEB or @FPRINT

Input:
1. Device name - Example DL1:[300,100]
2. Job name - Between 1 to 9 characters
3. Number of datasets – Up to 8 sets can be printed at a time.
4. Dataset numbers - Example 2 4 17
5. Side (Left/Right) - either L or R arranged in sequence with a space in between them. For example, for the jobs mentioned above (2,4,17), if we need left side data for 2,4 and right side data for 17, then the input to this question will be L L R
6. If interpolation is needed then answer Y to the next question and then input the number of points.
7. A code is assigned from 0 to 4 for different parameters
   0 for complete data
   1 for vertical force only
   2 for fore-aft shear force only
   3. for torque only
   4. for medio-lateral shear force only

Flexibilities:
Data can be in any user directory. Data can be compressed or expanded to any number of points between 20 & 600. Generally 64 points are suggested.

Compilation
PAS PFORCEB
Task builder
@PFORCEBT
Print Gait Parameters for a specified job

Program Sequence:

Open TEM.TXT;1 and read the job name.

Read the data directory from DEV.TXT;1. If DEV.txt;1 does not exist then get the directory from the operator and save the name of the directory in DEV.TXT;1. If you need to get a file from a different directory, then DELETE DEV.TXT;1 and rerun the program.

Read the text file BU.TXT;1 to get either B(for Bilateral) or U(Unilateral). Please note that if the direction of walking is positive X-axis for both right and left side data, then it is considered as Bilateral. If BU.TXT;1 does not exist in the current directory, then this Character is obtained from the operator and a new file BU.TXT;1 is created.

For Bilateral data the side name(Either left or right) is obtained from the operator.

Assign the parameter file name and open the file. Extension of the parameter file name is .PAF for Unilateral, .PER for Bilateral Right side, and .PEL for Bilateral Left side.

Read all parameters.

Write them on the terminal.

The parameters were written in a different sequence than it appears in the parameter file. You can use the command TYPE to type the parameter file and get the order of data appear in parameter file.

(An example TYPE DL1:[300,100]xxxxxxxxx.PER;1 here the job name is xxxxxxxx which is Bilateral right limb analysis.)
Unlike many modern software applications, the Helen Hayes Software is a collection of individual programs that each performs a limited number of functions. Therefore, most of the user procedures involve running a command (or script) file that runs a number of these programs, one after another, in sequence, to perform an analysis or display function. Each of these command files starts with the following RSX11M indirect commands to suppress the display of the actual command file contents as the script is run:

```
.ENABLE SUBSTITUTION
.ENABLE QUIET
.DISABLE DISPLAY
```

These lines are shown in the first command file below but have been removed from the following listings for clarity together with the terminating command:

```
.EXIT
```

Thus the rest of the following command files are shown in an abbreviated form with brief comments following the “!” character.

### A1GPLOT.CMD

```
.ENABLE SUBSTITUTION
.ENABLE QUIET
.DISABLE DISPLAY
RUN [1,15]TEMB  ! Update TEM, DEV, TEM1 and BU status.
RUN [1,15]APBG  !
.EXIT
```

### A1PLOT.CMD

```
RUN [1,15]TEMB  !
RUN [1,15]APRB  !
```

### A3PLOT.CMD

```
RUN [1,15]TEMB  !
RUN [1,15]AP3B  ! Plot angles
```
A.CMD
Get the gait parameters and plot the joint angles.
RUN [1,15]GPCB ! Calculate Gait Parameters
RUN [1,15]ACCB ! Angle calculation (segment relative)
RUN [1,15]APBR ! Angle plotting

AAD.CMD
RUN [1,15]FPC !

AG.CMD
Plot the joint angles relative to the ground.
RUN [1,15]GPCB ! Calculate Gait Parameters
RUN [1,15]ASB ! Smooth TR3 data and create SMO file
RUN [1,15]ACGB ! Angle calculation
RUN [1,15]APBG ! Angle plotting

AGPLOT.CMD
RUN [1,15]TEMB !
RUN [1,15]APBG !

ANGLE.CMD
Plot all eleven angles with subject information
RUN [1,15]TEMB !
RUN [1,15]APBJ !

APLOT.CMD
Plot all eleven angles.
RUN [1,15]TEMB !
RUN [1,15]APBR !

APRINT.CMD
Print existing angle data
RUN [1,15]PANGLEB !

AS.CMD
Calculate the rotation angles from condyle markers.
RUN [1,15]GPCB ! Calculate Gait Parameters
RUN [1,15]ASB ! Smooth TR3 data and create SMO file
RUN [1,15]ACSB !
RUN [1,15]APB !
CLEANUP.CMD
Delete all temporary files.
DEL VD2:[300,100]*.E01;*  !
DEL VD2:[300,100]*.E03;*  !
DEL VD2:[300,100]*.SMO;*  !
DEL VD2:[300,100]*.SMF;*  !
DEL VD2:[300,100]*.ANF;*  !
DEL VD2:[300,100]*.FPF;*  !
DEL VD2:[300,100]*.FPM;*  !

E.CMD
RUN [1,15]ECGFF  !
RUN [1,15]ECGAITP  !
RUN [1,15]ECSE  !
RUN [1,15]ECSTM  !
RUN [1,15]ECAV  !
RUN [1,15]ECFPLOT1  !

EC.CMD
Change EMG gait cycles
RUN [1,15]ECHANGE  !
RUN [1,15]ECGAITP  !

ECAL.CMD
Calibrate EMG data.
RUN [1,15]TEMB  !
RUN [1,15]ECAL  !

EGP.CMD
Print EMG gait parameters.
RUN [1,15]TEMB  ! Update TEM, DEV, TEM1 and BU status.
RUN [1,15]GP  !

EPLOT.CMD
Plot Averaged EMG data
RUN [1,15]TEMB  ! Update TEM, DEV, TEM1 and BU status.
RUN [1,15]ECFPLOT  !

ERAW.CMD
Plot raw EMG data.
RUN [1,15]TEMB  ! Update TEM, DEV, TEM1 and BU status.
RUN [1,15]ECFRPLOT ! Display raw EMG data.

**ERPLOT.CMD**

RUN [1,15]TEMB ! Update DEV, TEM, BU status
RUN [1,15]ECFRPLOT ! Display raw data.

**F1.CMD**

RUN [1,15]FPCC1B
RUN [1,15]FPC3PLOT !

**F.CMD**

Force calculation and plotting
.ASKS X HAVE YOU RUN @AAD
RUN [1,15]FPCCBU !

**FORCE.CMD**

Plot force data and subject information.
RUN [1,15]TEMB !
RUN [1,15]FPCPLOTJ !

**FPLOT.CMD**

Plot forces
RUN [1,15]FPC3PLOT !

**FPRINT.CMD**

Print existing force data.
RUN [1,15]PFORCEB !

**G.CMD**

Gait parameter calculation
RUN [1,15]GPCB ! Calculate gait parameters

**GPRINT.CMD**

Print existing gait parameters.
RUN [1,15]P GAITPB !

**M.CMD**

Joint moment calculation and plotting.
RUN [1,15]GPCB ! Gait events and parameters
RUN [1,15]MSB ! Smooth TR3 data for moment calculation
RUN [1,15]MCB    ! Absolute angle and joint center calculation
RUN [1,15]MFFCB  ! Read force data for moment calculation
RUN [1,15]M1B     ! Moment calculation
RUN [1,15]MP2B    ! Moment plotting

**MPLLOT.CMD**

Plot moments
RUN [1,15]TEM1B   ! Update TEM, DEV, TEM1 and BU status.
RUN [1,15]MP2B    !

**MPRINT.CMD**

RUN [1,15]PMOMENT !
Temporary Files Used

The Helen Hayes Software uses a large number of temporary files to pass parameters from one program to another and control the data analysis environment. The contents of these files will vary from installation to installation and also depending on the operating system.

Files generated on an RSX11M system will store data using the RADIX50 format while files created on a VMS system will generally use plain ASCII format. RADIX50 is an upper case only character set used in by DEC to pack as many characters into as few bits as possible.

**AFILE.TXT**
Contains a pointer to the location of the NORMAL.ANG file.

**BASEADC.TXT**

**BU.TXT**
Contains a single character flag to identify Bilateral (B) versus Unilateral (U) data.

**CHANNEL.TXT**
Contains two ADC channel numbers for analog footswitches.

**CHANNEL1.TXT**

**CHANNELE.TXT**
Contains a list of EMG channels.

**CP.TXT**
Center of Pressure Plot (Y or N).

**DEV.TXT**
Pointer to device and directory for job data.

**ECHANNEL.TXT**
Contains a list of EMG channels.

**EGAIN.TXT**
EMG electrode gain list
**ESCALE.TXT**
EMG graphing scale.

**FCHANNEL.TXT**

**FCORR.TXT**
Contains the force plate correction matrix for AMTI force plates.

**FFILE.TXT**
Pointer to the location of the NORMAL.FPX file.

**FMOD.TXT**

**FPARA.TXT**

**HOS.TXT**
Title line "Ground Reaction Forces"

**HOS1.TXT**
Title line "Joint Moments"

**HOS2.TXT**
Title line "Site Name"

**HOS3.TXT**
Title line "Site Name - Gait Analysis"

**MAL.TXT**
List of marker numbers for LHS.

**MAR.TXT**
List of marker numbers for RHS.

**MARSL.TXT**
List of marker numbers

**MARSR.TXT**
List of marker numbers
**MF.TXT**
Force scaling factor.

**MFILE.TXT**
Pointer to the location of the NORMAL.MOM file.

**NORM.TXT**
EMG on/off activity list.

**NORMAL.AAG**
A normal data file containing averaged angles?

**NORMAL.ANG**
A normal data file containing?

**NORMAL.FPX**
A normal data file containing forces?

**NORMAL.MOM**
A normal data file containing moments?

**NORMAL.PAF**
A normal data file containing?

**REF.TXT**
Segment/Ground Reference angle flag.

**SCALE.TXT**
Default scales for Angle Plots.

**ST.TXT**
Static Correction markers

**TEM.TXT**
Temporary file produced for each analysis - contains file name, SMO and dataset number.
TEM1.TXT
Contains Right/Left analysis side flag.

TER. TXT
Contains the graphics terminal type.
Index

No index entries found.