

## 3D Motion Analysis in Movement Disorders



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## Introduction

The method for analysing movement disorders is based on a measuring system for 3-dimensional motion analysis according to the principle of the travel time measurement of ultrasound pulses.

The measuring site consists of a basic system, a measuring sensor with stand and ultrasound markers.

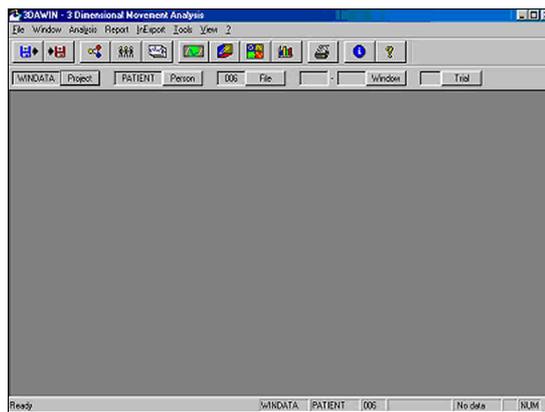
The chronological spatial coordinates of up to 8 markers are recorded with a total sampling rate of 200 Hz (dependent on the system) by the measurement recording program WinData. Data recording can be monitored in realtime directly on the screen. WinData is running under up to date Windows operating systems.

The 3DAWIN program is developed by the Neuropsychology Research Group (City Hospital Munich-Bogenhausen) for the analysis of three-dimensional motion data. It runs under Windows OS and allows the investigation of the hand and arm function by analysis of the dynamic motion parameters.

The data can be analysed in 3DAWIN by means of interactive graphics and statistics routines. For this purpose, the program makes use of the exported binary data files and patient data provided by WinData.

In 3DAWIN, three of the markers are selected and analysed simultaneously. All analytical combinations are possible within such a group of three markers. For example, travel, distances and angles can be calculated as well as the corresponding velocity and acceleration in three dimensions or in specific position planes. The results of all used markers are represented in the results printout.

With the 3DA program, the solid angle, and for each marker, the relative (x, y, z) and absolute three-dimensional curve with the corresponding development of velocity and acceleration can be calculated. Specific data filtering (adjustable) efficiently suppresses system-inherent errors, especially in the derivatives.



3DAWIN can be operated by the menu bar or the icons with the mouse, even without experience in electronic data processing systems. Major program functions can also be called up from any menu with function keys; for the experienced user, this makes paging through the individual menu levels during evaluation unnecessary. The software is available in German and English.

Integrated "standard routines" make 3DAWIN highly suitable for use by several people, for example in the daily routine in clinics. Due to its flexible evaluation routines, the integrated macro instruction languages and the standardized interfaces with other program systems (data import/export, storage of measured values and parameters), 3DAWIN is also particularly useful for experimental purposes.

## Error control

Measured data are analysed for each marker separately with regard to errors when the file is read in. Up to two successive measurement errors are reconstructed by 3DAWIN by interpolation of the corresponding development of velocity and subsequent computational reconstruction for the actually travelled distance. These measurements are displayed in a different colour for identification. The number of corrected and still uncorrected errors is indicated.

Because system-inherent errors regarding spatial coordinates (resolution = 0.1 mm) are multiplied by the data frequency when derivations are calculated (i.e. by the data frequency to the power of two for acceleration values), valid data filtering must be of special importance.

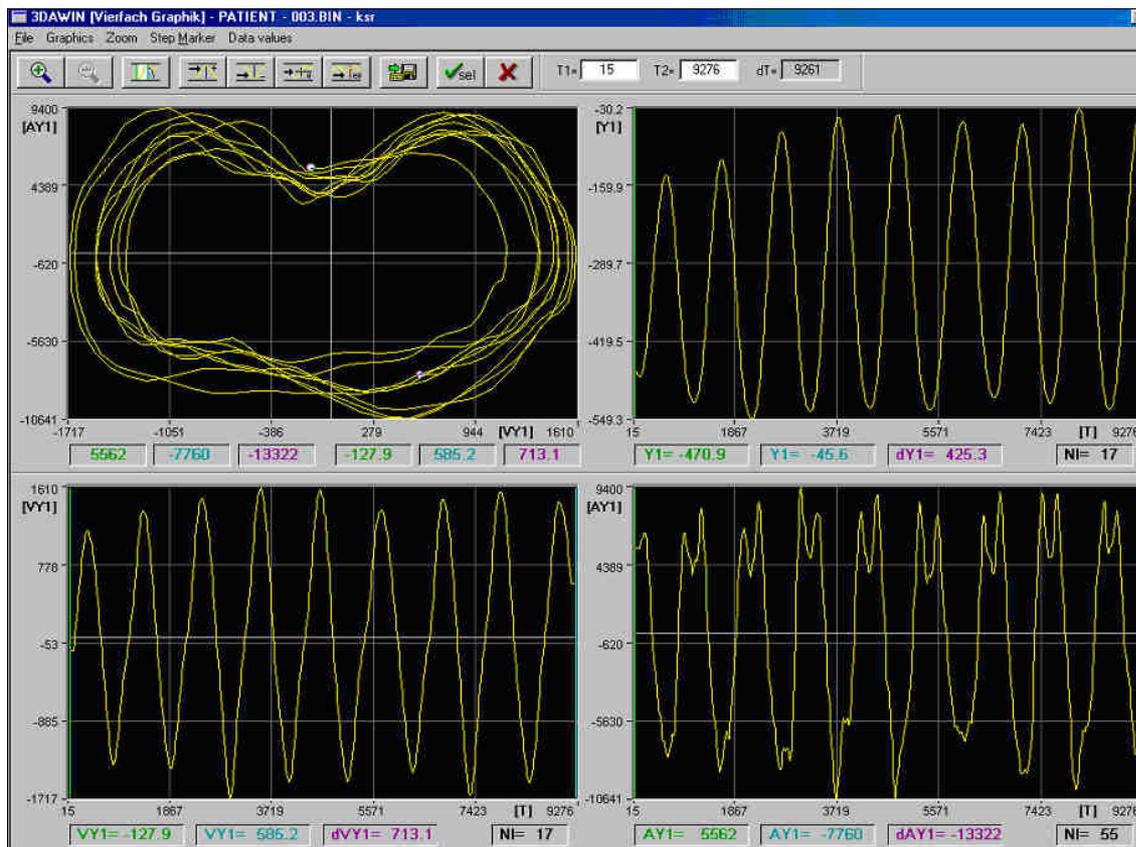
With specific algorithms (fourth-order non-parametric core estimation), a type of sliding weighted averaging and simultaneous derivation of the data, 3DAWIN can reduce these errors to insignificant levels.

## Data filtering

For motion analysis, 3DAWIN can calculate for each marker the projection in the spatial axes x, y, z, and the absolute spatial curves, the angle of a segment defined by two markers in relation to the horizontal line

and, for three markers, the angle between the two segments. In addition, the corresponding development of velocity and acceleration can be calculated from all variables.

## Graphic analysis

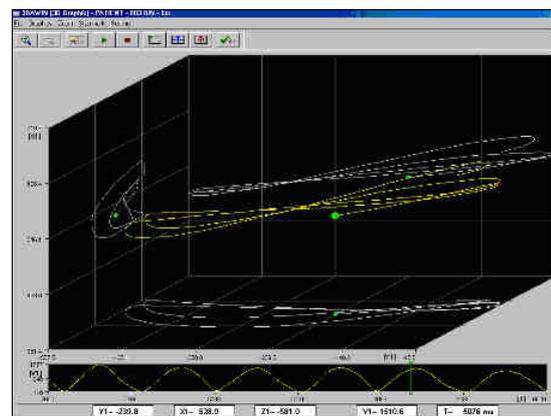


Selected segments of recorded movements are presented as phase-plots together with the corresponding velocity and acceleration profiles. A large number of parameters are provided for quantitative analysis.

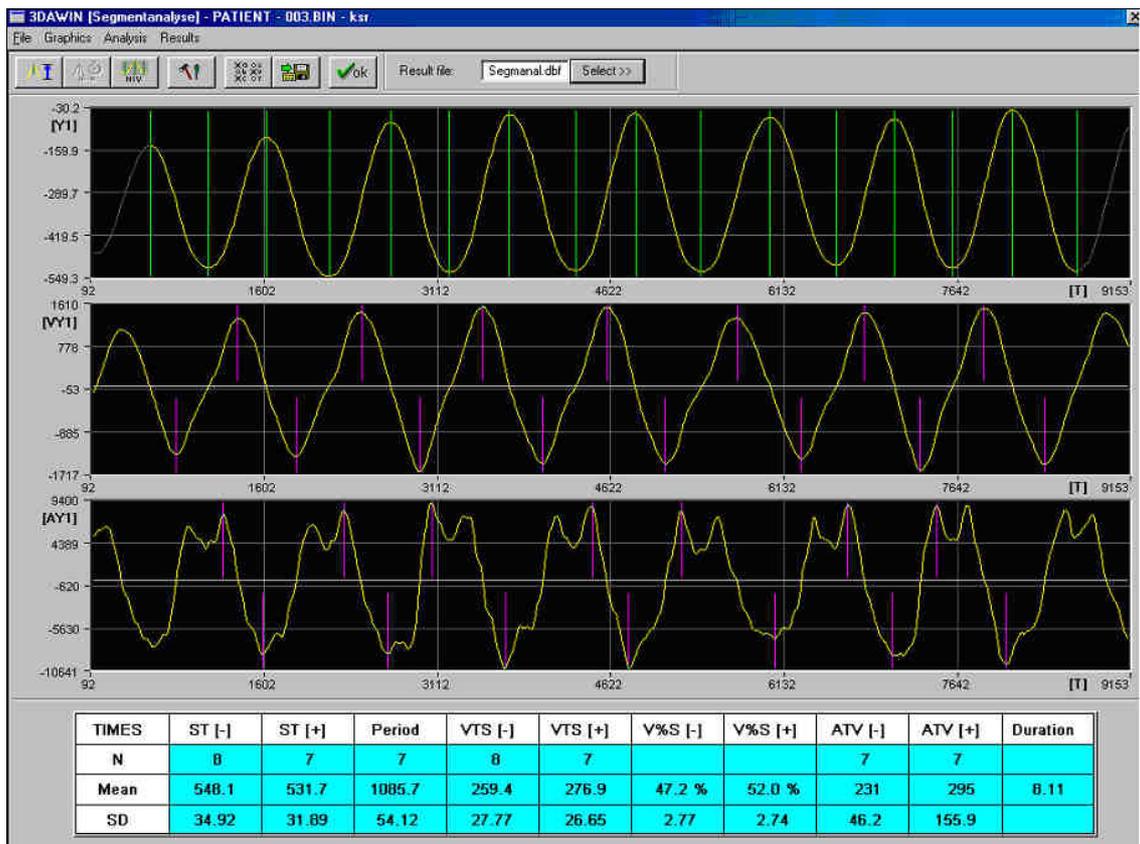
As an initial step the sections to be analysed can be selected from the original curve in a measured data file. During this procedure any faulty section which has not been detected by WinData as such (as, for example, possible in case of reflections) can be marked as erroneous. In this case, the corresponding spatial curves are extrapolated across the marked area. Subsequently calculated time curves and phase plots can be displayed and analysed on the monitor as single graphics or as four subdivided-screen graphics.

Motion sequences can be observed here in detail with simultaneous display of spatial curves and velocity and acceleration development. Markings can be set and dragged with the mouse cursor.

The displayed corresponding measured data and difference values can be stored. Auxiliary functions such as jumping to the next peak or zooming of selected portions of a curve facilitate this type of analysis.



## Statistical analysis



Analysis of the automation of repetitive movements is particularly supported by the system. Selected movement parameters are presented graphically and quantitatively for analysis of regularity and stability over time

Characteristic quantities such as mean segment length, peaks of velocity and acceleration, number of motion changes or the resulting segment frequency can be calculated and processed interactively for definable curve segments by means of statistical evaluation routines. This type of evaluation is especially suited for analysing repetitive motions.

In an initial step the locus curve is segmented to form individual strokes (usually in y direction). For segment selection, specific boundary conditions such as size and time criteria or minimum changes to be taken into consideration can

be preset. In addition, the segment boundaries found according to these criteria can be shifted, removed, or data sections can be entirely excluded from analysis.

In a second step, statistical characteristics are calculated on the basis of the segments defined as described above. Mean values and standard deviation are shown on the monitor screen and stored if required.

In a further statistical evaluation routine, some characteristic values can be calculated and stored for any time curve or curve section, e.g. mean value, SD,...

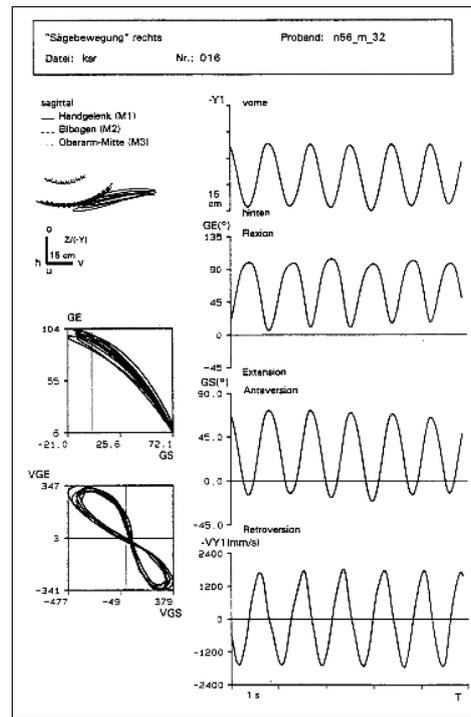
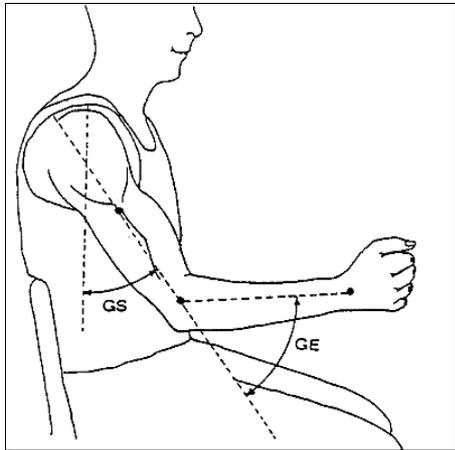
## Standard results printout

Complex graphic printouts can be programmed in the integrated text editor for a laser printer or a pin plotter with the integrated macro instruction language. All relevant parameters for variables, filters, position, scaling, type font etc. can be defined by means of a variety of easily understandable instructions.

```
orient=1
device=laser
file=xr990101
dimensx=t
dimensy=v
filtery=50
miny=min
maxy=200
textstr=@filename
print
```

Excerpt from a macro file

### Example: Sawing movement



Standard printout: Investigation of a sawing movement

From: Report 1/96  
Neuropsychology Research Group (City Hospital,  
Munich-Bogenhausen)  
Dr. J. Hermsdörffer, Dr. S. Wack  
Prof. Dr. N. Mai, Dipl. Ing. C. Marquardt

During the instruction file run the option of returning to the program menu for more complex data operations is given. Text entries and lines can be freely varied for graphic design of the printout. Standard printouts programmed in this manner can be used for any data without modification as the required variable parameters are entered during program run. This allows ideal graphic solutions to be created both for standard diagnosis sheets and for specific research purposes (publications).

## **Import/export of data**

Original measurement data can be exported/imported from 3DAWIN in ASCII and dBASE format. Filtered curves and their derivatives can be exported in ASCII format for analysis in other evaluation programs (such as spectral analysis). Individual measured data from various

curves at the same point in time, statistical parameters from segment analysis, such as mean peaks and changes, and statistical characteristics of a time curve are stored in dBASE format and can be further processed in statistical evaluation programs such as SPSS.

## **System configuration**

3DA requires the following system configuration:

- PC Pentium from 200 MHz on
- runs under up to date Windows operating systems
- min. 32 MB RAM
- VGA Graphik with min. 800 x 600 dpi
- color screen
- mouse