

Statistical Analysis of Cardiac Electric Vectors Using SAS®

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A research project to study the variability of the heart's Characteristic Electric Vector for possible use in diagnosing coronary artery disease required data collection from a study group and statistical analysis of the data. Measurements of the heart's electric field were obtained from each individual study group member and converted to digital form by utilizing a digital oscilloscope to initially collect the electric field strengths at the electrodes placed at various locations on the body of the subject. The electric field was sampled at the rate of 200 samples/sec. until fifty thousand points were obtained. This data in digital form was stored on floppy disks and transferred to the hard disk of a Personal Computer (PC) for statistical analysis.

The data analysis was performed using SAS 6.06 running under OS/2 2.0 on a 50 MHz 486DX IBM Model 95 personal computer (PC). Each electrode position at which data is collected results in a time series of 50,000 points.

The data comes in as a stream of numbers in a file. A DATA step is used to read the file and construct a matrix. If the input file has 50,000 readings, the resulting SAS data set will contain 49,991 observations and ten variables. The three dimensional electrical field vector of the heart representing all the instantaneous electrical fields produced by the muscle fibers in the heart can be analyzed by projecting this equivalent vector to the appropriate plane. An orthogonal reference-frame system was chosen. An example of the first axis electrical field plotted against time is given in figure 1. The data is seen to resemble the traditional EKG tracing. Figure 2 is a plot of the projection of component 1 versus component 2. By plotting the projection of the characteristic vector projected on the two dimensional planes important information can be deduced from these and other projections. However the visualization of the electric vector in three dimensions is the desirable goal. The arrangement of the data for visual analysis and the eventual visual display of the three dimensional data are discussed below.

The transformed components were then utilized to construct trajectories in phase space of the Characteristic Electric Vector. A discussion of the trajectories and graphical examples follows below. Although the early calculations were performed with SAS

6.06, it was decided to migrate to SAS 6.08 BETA when it became available because of the graphical analysis capabilities in the INSIGHT package.

Graphical Display of Data

Two approaches have been taken to display the calculated moments with SAS/GRAPH software. First, a macro was developed using the Data Step Graphics Interface to put four plots on a page with a title centered across the top. Each of the individual graphs is generated with the PLOT procedure and is a plot of one of the principal components against the other. If each PLOT has 10,000 points, the entire plot with four subplots takes less than a minute to run on a 50 MHz PC under OS/2 SAS 6.06.

The macro has arguments which allow the size, font, and text of the title to be specified. Additionally, a footnote can be given. This allows more space for the individual plots since there is only one title and footnote on the page. The macro sizes the four plots on the page so no distortion occurs for any individual plot. The macro is listed in Appendix B.

The second approach was to use SAS/INSIGHT software to generate scatter plots and rotating 3-dimensional plots. A SUN Sparcstation 2 with 6.07 SAS was used. Generating scatter plots for data sets with 10,000 observations takes only a few seconds. An example of such output is given in Figures 2 and 4. Three Dimensional (3D) plots can also be generated by SAS/INSIGHT from the data. Figures 5 and 6 are examples of 3D plots that can be rotated and manipulated interactively for data exploration. The use of the 3D rotating plot allows one to study the first three components to detect any abnormalities.

Pull-down menus were used to map the desired plot from the INSIGHT graphics window to a graphics catalog. Then the plot was sent to a graphics stream file; here the GOPTION SWAP was necessary to avoid a black background. The file was routed to an appropriate printer. In trying to import such a rotating 3-D plot into WordPerfect 5.1, it was discovered that using the CGMWP driver resulted in a graphics stream one-third the size of that generated by the PSEPSF (Encapsulated

Postscript) driver. Even so, the CGMWP graphics stream file for either Figure 2 or 5 was around 600,000 bytes. Reducing the marker size can help make the resulting graphics stream file smaller.

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APPENDIX A

```
%macro PLOT4PP(libn=work,catlg=gseg,t_height=0.5,
ttitle=title, tcolor=5,f_height=0,tfnote=fnote);
proc catalog cat=&libn.&catlg;
  contents out=plots;
data _null_;
  set plots;
  call symput('name'||left(_n_),name);
data _null_;
  fh=&f_height;
  if fh ne 0 then fheight=fh+.125;
  else fheight=0;
  call gask('hsize',hsize,rc);
  call gask('vsize',vsize,rc);
  put 'hsize='hsize;
  put 'vsize='vsize;
  tpct=100*&t_height/7.5;
  fpct=100*&f_height/7.5;
  ylen=(7.5-&t_height-fheight-.25)/2;
  xlen=ylen*10/7.5;
  xleft=(10-0.5-2*xlen)/2;
  xrgt=xleft+xlen+0.5;
  rc=gset('catalog', "&libn", "&catlg");
  rc=ginit();
  rc=graph('clear');
  call gask('window',0,llx,lly,urx,ury,rc);
  textcnt = urx/2;
  rc=gset('texheight', tpct);
  rc=gset('texfont', 'swiss');
  rc=gset('texcolor', &tcolor);
  rc=gset('texalign', 'center', 'normal');
rc=gdraw('text',textcnt, 100 - tpct, "&ttitle");
  if fh ne 0 then do;
    rc=gset('texheight', fpct);
```

```
    rc=gdraw('text', textcnt, 0.5, "&tfnote");end;
  rc=gset('viewport', 1, xleft/10,
(ylen+0.125+fheight)/7.5, (xleft+xlen)/10,
(2*ylen+0.125+fheight)/7.5);
  rc=gset('viewport', 2, xrgt/10,
(ylen+0.125+fheight)/7.5, (xrgt+xlen)/10,
(2*ylen+0.125+fheight)/7.5);
  rc=gset('viewport', 3, xleft/10, (fheight)/7.5,
(xleft+xlen)/10, (ylen+fheight)/7.5);
  rc=gset('viewport', 4, xrgt/10, (fheight)/7.5,
(xrgt+xlen)/10, (ylen+fheight)/7.5);
  rc=gset('window', 1, 0, 0, 100, 100);
  rc=gset('window', 2, 0, 0, 100, 100);
  rc=gset('window', 3, 0, 0, 100, 100);
  rc=gset('window', 4, 0, 0, 100, 100);
  rc=gset('transno', 1);
  rc=graph('insert', "&name1");
  rc=gset('transno', 2);
  rc=graph('insert', "&name2");
  rc=gset('transno', 3);
  rc=graph('insert', "&name3");
  rc=gset('transno', 4);
  rc=graph('insert', "&name4");
  rc=graph('update');
  rc=gterm();
run;
%mend;
```

ACKNOWLEDGEMENTS

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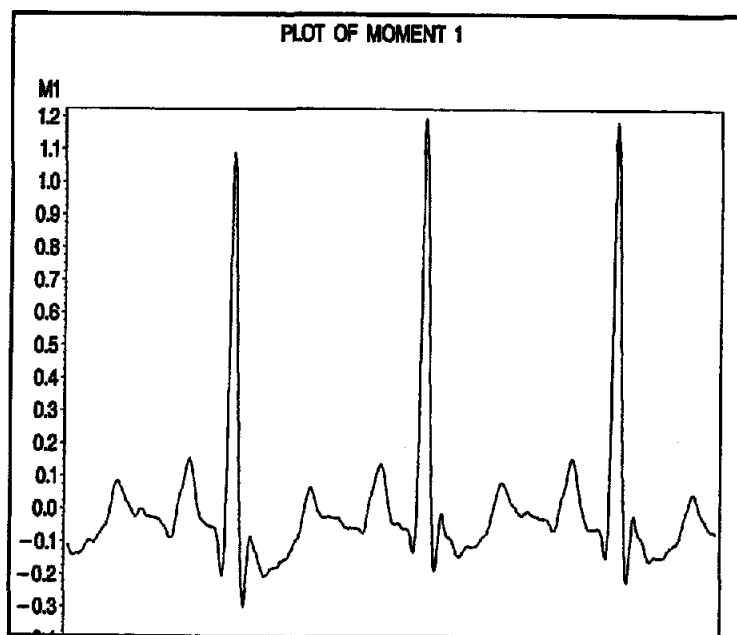


Figure 1 Plot of component 1 versus time

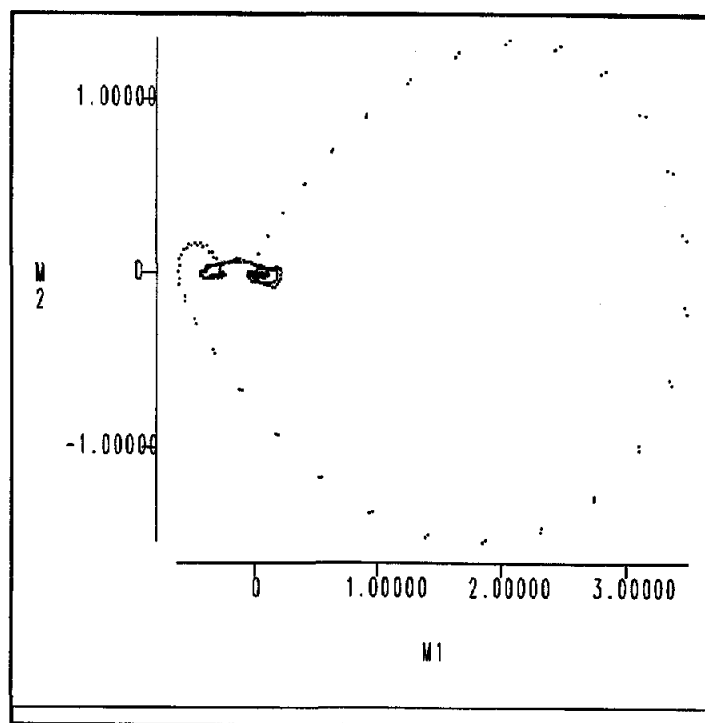


Figure 2 Component 2 versus component 1

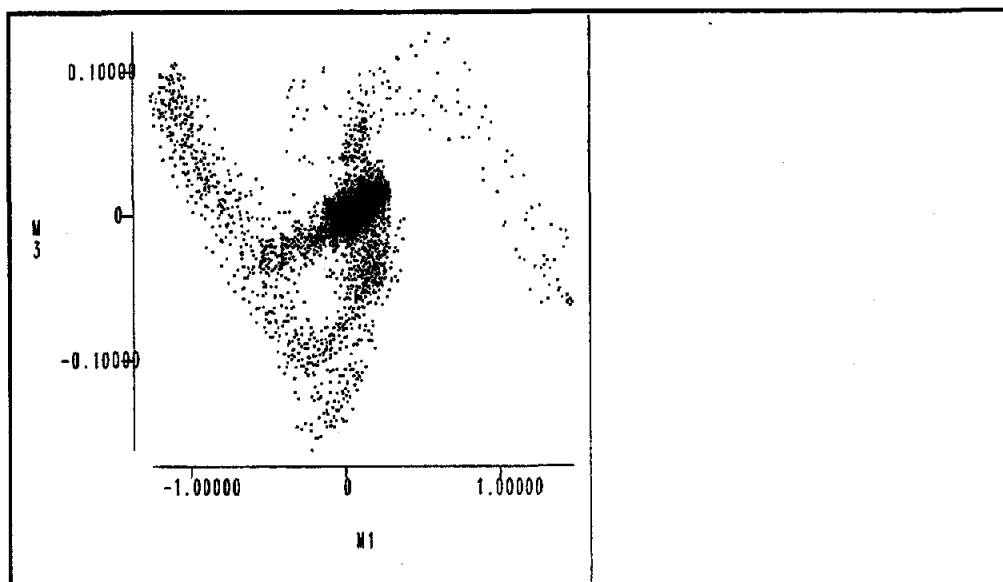


Figure 3 Plot of m_3 versus m_1

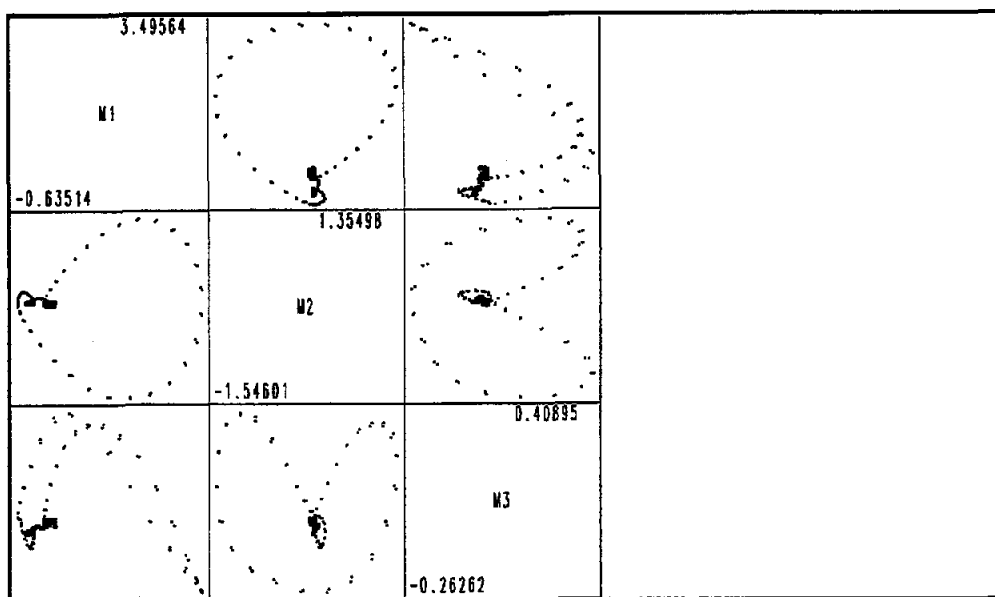


Figure 4 Output from INSIGHT analysis

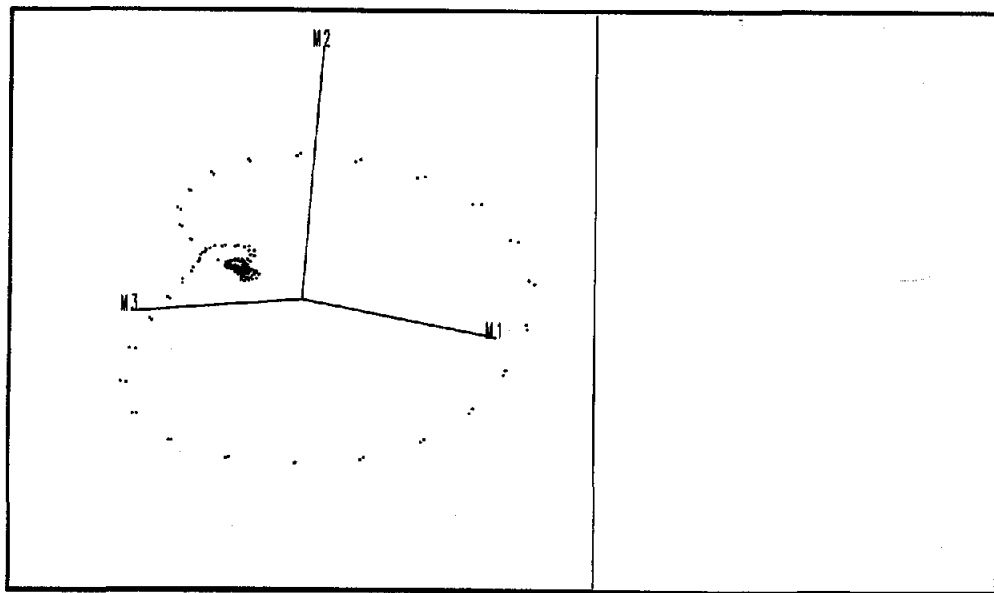


Figure 5 Three Dimensional Display of data

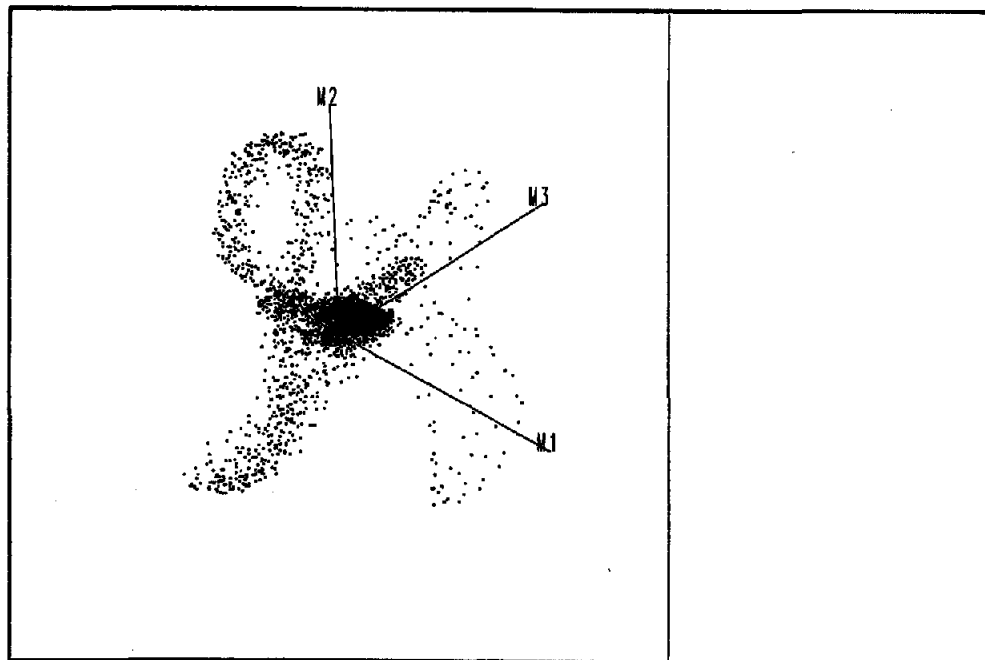


Figure 6 Insight display of data