```
% Este programa lee los datos de ECG los cuales estan guardados con el
% formato 212 y datos de oximetria y respiración guardados en formato
 16
% de la base de datos APNEA-ECG disponibles en physionet.org
% Las anotaciones han sido preparadas basadas en la revisión visual de
% un experto revisando simultaniamente las señales de respiracion y
% saturación de oxigeno.
% Cuando estos archivos fueron publicados, la siguiente (incorrecta)
% descripción de apnean fue usada:
% En estos archivos, un "8" indicua que ocurre un evento apenico
 durante el
% siguiente intervalo de un minuto, y un "1" indicua que no existe
 apnea
% durante el siguiente intervalo de un minuto.
%
%
%      created on 2015 by
%      Santiago Arevalo (National University of Entre Rios)
%      (email: sarevalog@correo.udistrital.edu.co),
%
%      algorithm is based on a program written by
%      Klaus Rheinberger (University of Innsbruck)
%      (email: klaus.rheinberger@uibk.ac.at)
%
%
 -------------------------------------------------------------------------
clc; clear all;

PATH= '/home/sarevalog/Dropbox/MAESTRIA/THESIS/CODIGOS/MATLAB/
RESPIRATORY';

%Lee la señal ECG de un archivo y las señales respiratorias de otro

sig='a01';

HEADERFILE= [sig 'er' '.hea'];      % header-file in text format

DATAFILEECG=[sig '.dat'];         % data-file

DATAFILERES=[sig 'r' '.dat'];         % data-file

ATRFILE = [sig 'r' '.apn'];       % apnea annotations

% ------ CARGA ENCABEZADO DE LOS DATOS
 ------------------------------------

fprintf(1,'\\n$> WORKING ON %s ...\n', HEADERFILE);
signalh= fullfile(PATH, HEADERFILE);
fid1=fopen(signalh,'r');
z= fgetl(fid1);
A= sscanf(z, '%*s %d %d %d',[1,3]);
nosig= A(1);  % number of signals
```

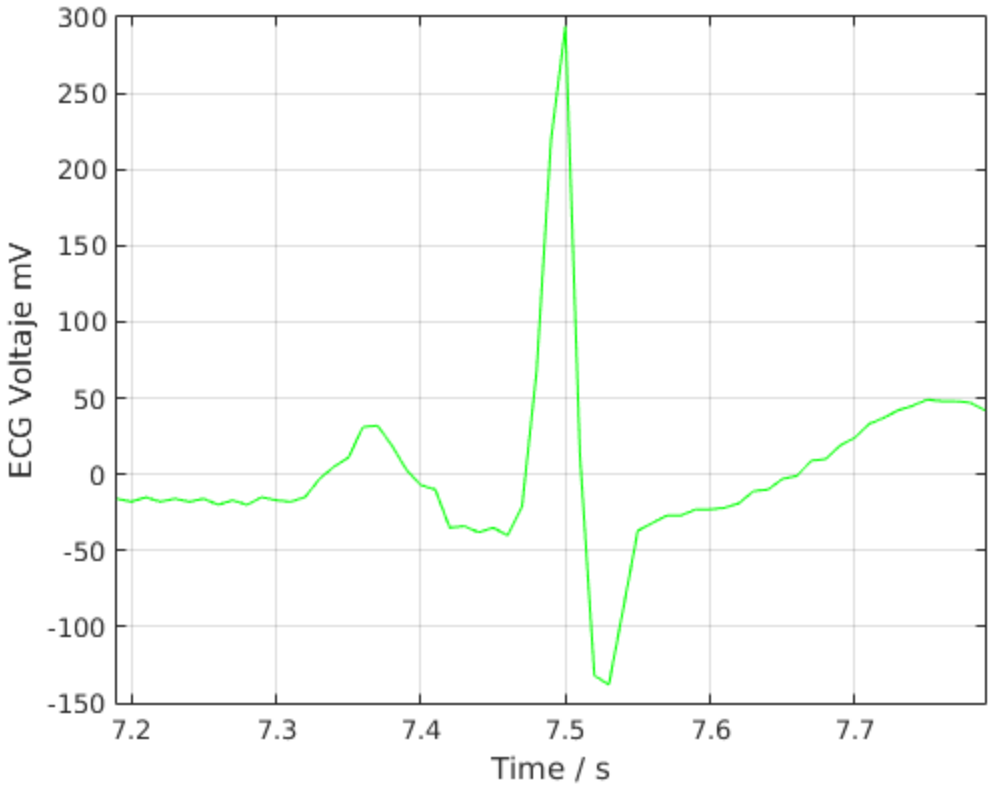
```
sfreq=A(2);   % sample rate of data
samples = A(3);
clear A;
for k=1:nosig
    z= fgetl(fid1);
    A= sscanf(z, '%*s %d %d %d %d %d %d %d %*s',[1,5]);
    dformat(k)= A(1);           % format;
    gain(k)= A(2);              % number of integers per mV
    bitres(k)= A(3);            % bitresolution
    zerovalue(k)= A(4);         % integer value of ECG zero point
    firstvalue(k)= A(5);        % first integer value of signal (to
 test for errors)
end;
fclose(fid1);
clear A fid1;
%
%------ CARGA DATOS BINARIOS
 ------------------------------------------------
%-------
%-------ECG
%-------

signalECG= fullfile(PATH, DATAFILEECG);           % data in format
 212
fid2=fopen(signalECG,'r');                        %'r' open file for
 reading
A= fread(fid2, [2,inf], 'uint8')';                % matrix with 3
 rows, each 8 bits long, = 2*12bit
fclose(fid2);

M1HA= bitand(A(:,2), 15);
PRLA=bitshift(bitand(A(:,2),8),9);     % sign-bit
ECG( : , 1)= bitshift(M1HA,8)+ A(:,1)-PRLA;
if ECG(1,1) ~= firstvalue, error('inconsistency in the first bit
 values'); end;

clear M1HA PRLA A;

%-------
%------- RES
%-------

signalRES= fullfile(PATH, DATAFILERES);           % data in format 16
fid3=fopen(signalRES,'r');                        %'r' open file for
 reading
B = fread(fid3,[4,inf], 'uint16')';               % matrix with 4
 rows
fclose(fid3);
n=length(B);

RES= zeros(samples, 4);                                  %
 preallocating

for k=1:n
```

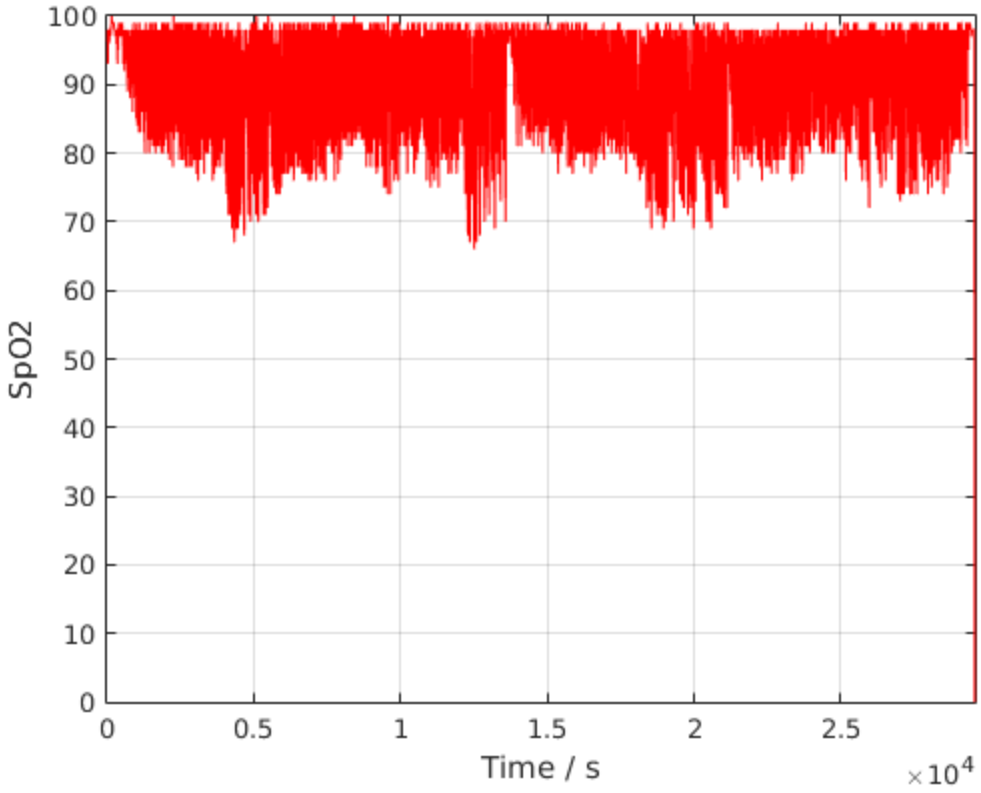
```
    val1 = B(k,1);
    val2 = B(k,2);
    val3 = B(k,3);
    val4 = B(k,4);
    y1 = sign(2^(16-1)-val1)*(2^(16-1)-abs(2^(16-1)-val1));
    y2 = sign(2^(16-1)-val2)*(2^(16-1)-abs(2^(16-1)-val2));
    y3 = sign(2^(16-1)-val3)*(2^(16-1)-abs(2^(16-1)-val3));
    y4 = sign(2^(16-1)-val4)*(2^(16-1)-abs(2^(16-1)-val4));

    if ((y1 == 0) && (val1 ~= 0))
    RES(k , 1) = -val1;
    else
    RES(k , 1) = y1;
    end

    if ((y2 == 0) && (val2 ~= 0))
    RES(k , 2) = -val2;
    else
    RES(k , 2) = y2;
    end

    if ((y3 == 0) && (val3 ~= 0))
    RES(k , 3) = -val3;
    else
    RES(k , 3) = y3;
    end

    if ((y4 == 0) && (val4 ~= 0))
    RES(k , 4) = -val4;
    else
    RES(k , 4) = y4;
    end
end;

clear val1 val2 val3 val4 y1 y2 y3 y4 n fid2 fid3;

for k=2:nosig

    RES( : , k -1 )= (RES( : , k -1)- zerovalue(k))/gain(k);

end;
TIME=((0:(samples-1))/sfreq)';
signal =[TIME , ECG , RES];

clear ans bitres B dformat ECG firstvalue gain k nosig RES samples;
clear signalECG signalh signalRES z zerovalue;

fprintf(1,'\\n$> LOADING DATA FINISHED \n');

%------ CARGA LAS ANOTACIONES
 -----------------------------------------

atrd= fullfile(PATH, ATRFILE);      % attribute file with annotation
 data
```

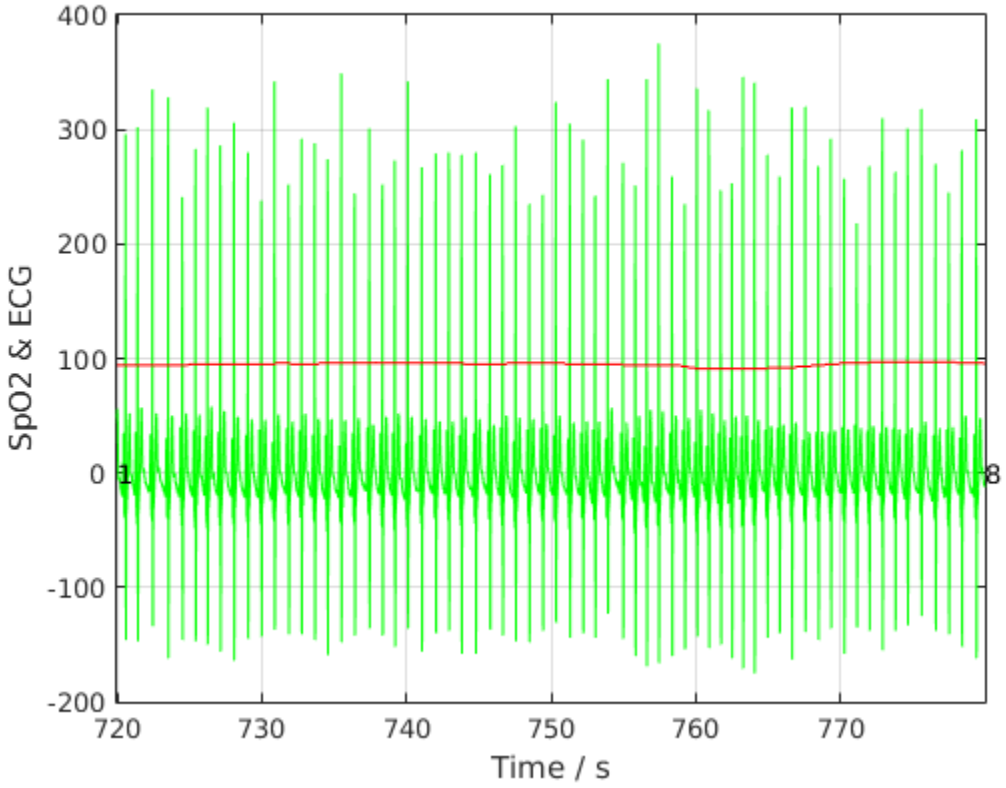
```
fid3=fopen(atrd,'r');
A= fread(fid3, [2, inf], 'uint8')';
fclose(fid3);

ANNOT=[];
ATRTIME = [];
sa=size(A);
saa=sa(1);

i=1;
while i <= saa
    annoth = bitshift(A(i,2),-2);
    if annoth == 59
        ANNOT = [ANNOT;bitshift(A(i + 3,2),-2)];
      ATRTIME = [ATRTIME;A(i+2,1) + bitshift(A(i + 2,2),8) +
 bitshift(A(i + 1,1),16) + bitshift(A(i + 1,2),24)];
        i = i + 3;
    elseif annoth == 60
    elseif annoth == 61
    elseif annoth == 62
    elseif annoth == 63
        hilfe = bitshift(bitand(A(i,2),3),8) + A(i,1);
        hilfe = hilfe + mod(hilfe,2);
        i = i + hilfe/2;
    else
        ATRTIME = [ATRTIME;bitshift(bitand(A(i,2),3),8) + A(i,1)];
        ANNOT = [ANNOT;bitshift(A(i,2),-2)];
   end;
   i = i + 1;
end;

ANNOT(length(ANNOT)) = [];                  % Last Line = EOF (= 0)
ATRTIME(length(ATRTIME)) = [];              % Last Line = EOF
ATRTIME = (cumsum(ATRTIME))/sfreq;
ind = find(ATRTIME <= TIME(end));
ATRTIMED = ATRTIME(ind);
ANNOT = round(ANNOT);
ANNOTD = ANNOT(ind);
apnea = [ATRTIMED , ANNOTD];

%---------MUESTRA DATOS
 ------------------------------------------------

figure(1); clf, box on, hold on, grid on;

liminf=720; limsup=780;
plot(signal(liminf:limsup,1),signal(liminf:limsup,2),'g');   %cambio
 de resp normal a apnea

xlim([TIME(liminf), TIME(limsup)]);
xlabel('Time / s');
ylabel('ECG Voltaje mV');
```

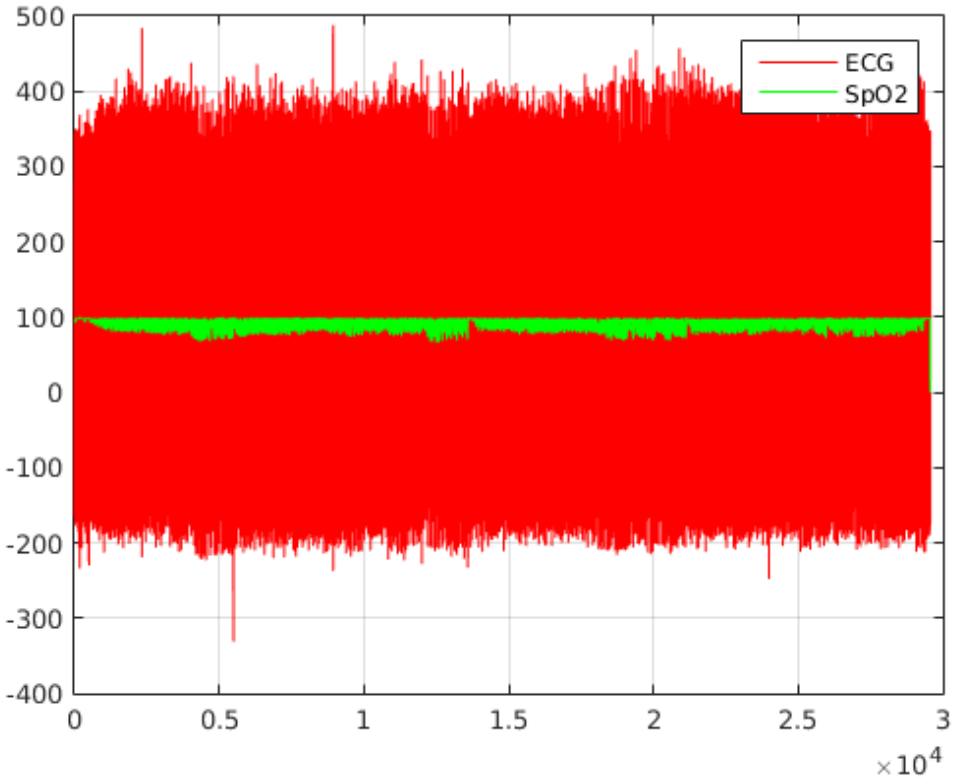
```
figure(2); clf, box on, hold on, grid on;

plot(signal(:,1),signal(:,6),'r');

xlim([TIME(1), TIME(end)]);
xlabel('Time / s');
ylabel('SpO2');

figure(3); clf, box on, hold on, grid on;

liminf=72000; limsup=78000;

plot(signal(liminf:limsup,1),signal(liminf:limsup,2),'g');   %cambio
 de resp normal a apnea
plot(signal(liminf:limsup,1),signal(liminf:limsup,6),'r');

for k=13:14
    text(ATRTIMED(k),0,num2str(ANNOTD(k)));
end;
xlim([TIME(liminf), TIME(limsup)]);
xlabel('Time / s');
ylabel('SpO2 & ECG');


figure(4); clf, box on, hold on, grid on;

plot(signal(:,1),signal(:,2),'r');
plot(signal(:,1),signal(:,6),'g');
legend('ECG','SpO2');

figure(5); clf, box on, hold on, grid on;


liminf=60000; limsup=100000;

plot(signal(liminf:limsup,1),signal(liminf:limsup,2),'g');   %cambio
 de resp normal a apnea
plot(signal(liminf:limsup,1),signal(liminf:limsup,6),'r');

for k=11:17
    text(ATRTIMED(k),0,num2str(ANNOTD(k)));
end;
str = '8 = APNEA 1 = NORMAL';
text(625,350,str)

xlim([TIME(liminf), TIME(limsup)]);
xlabel('Time / s');
ylabel('SpO2 & ECG');
legend('ECG','SpO2');


clear A ANNOT ANNOTD annoth ans ATRTIME ATRTIMED fid3 i ind sa saa sfreq TIME;
fprintf(1,'\\n$> DISPLAYING DATA FINISHED \n');
```

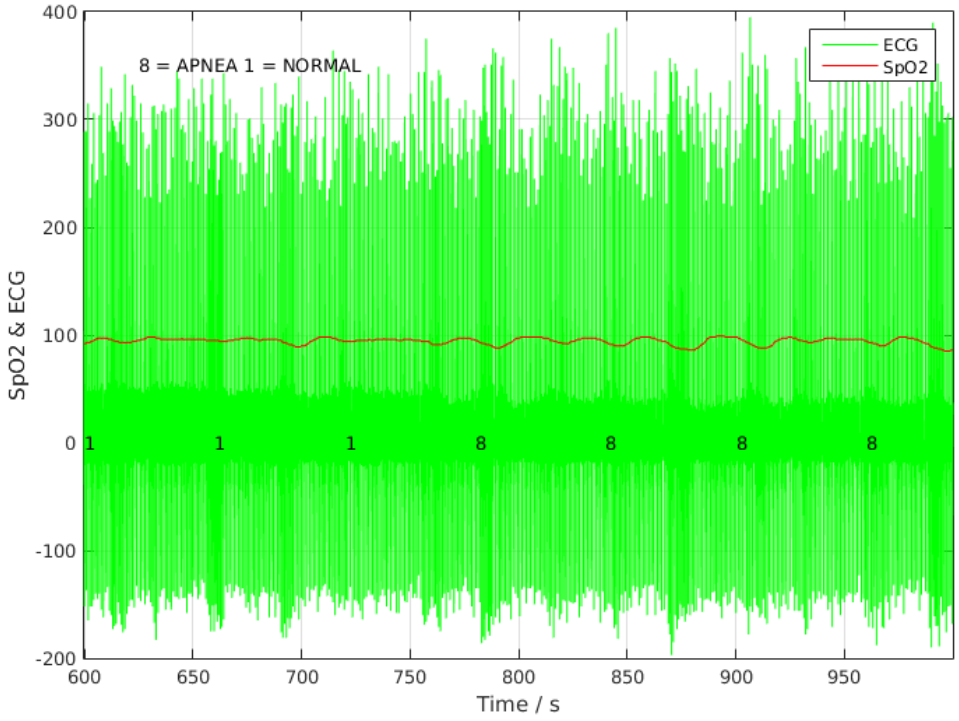
```
\n$> WORKING ON a01er.hea ...
\n$> LOADING DATA FINISHED
\n$> DISPLAYING DATA FINISHED
```




100
90
80
70
60
50
40
30
20
10
0
SpO2
0
0.5
1
1.5
2
2.5
Time / s
×10^4


400
300
200
100
0
-100
-200
SpO2 & ECG
720
730
740
750
760
770
Time / s


ECG
SpO2
500
400
300
200
100
0
-100
-200
-300
-400
0
0.5
1
1.5
2
2.5
3
×10^4


8 = APNEA 1 = NORMAL
ECG
SpO2
SpO2 & ECG
Time / s
400
300
200
100
0
-100
-200
600
650
700
750
800
850
900
950
1
1
1
8
8
8
8

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