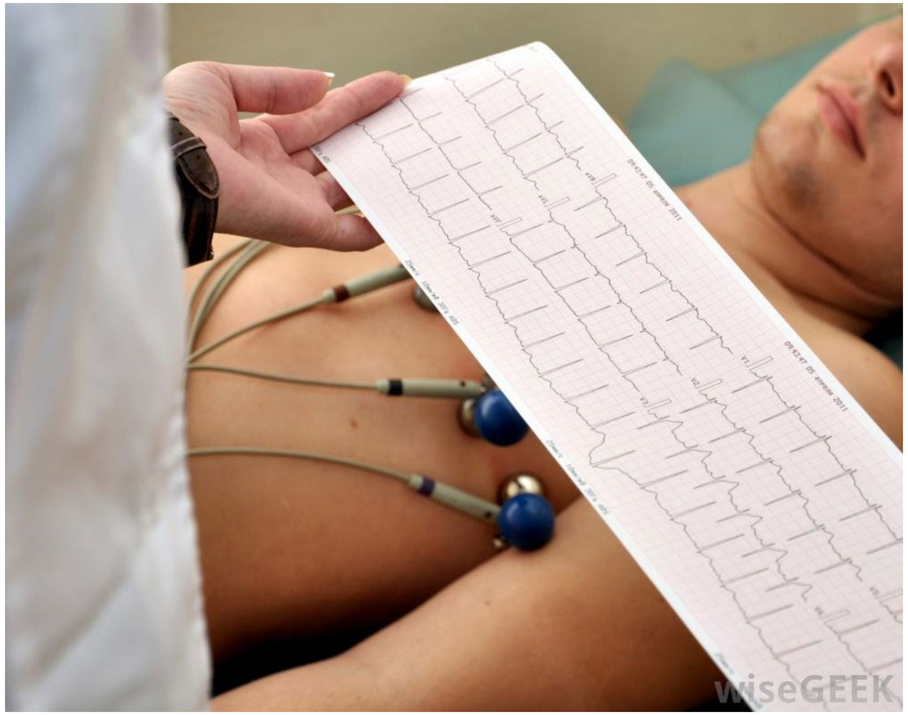
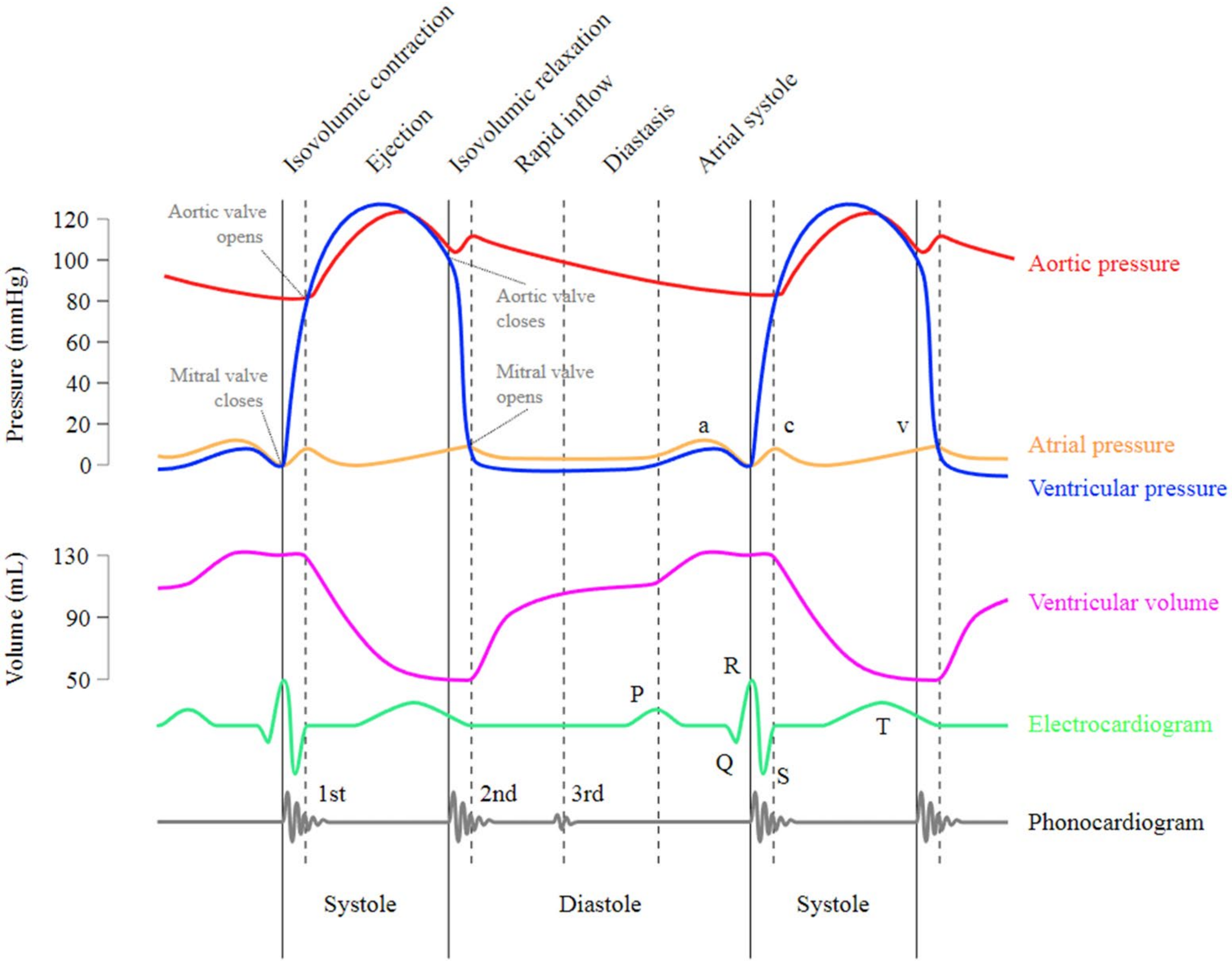
# ECG Signal Classification

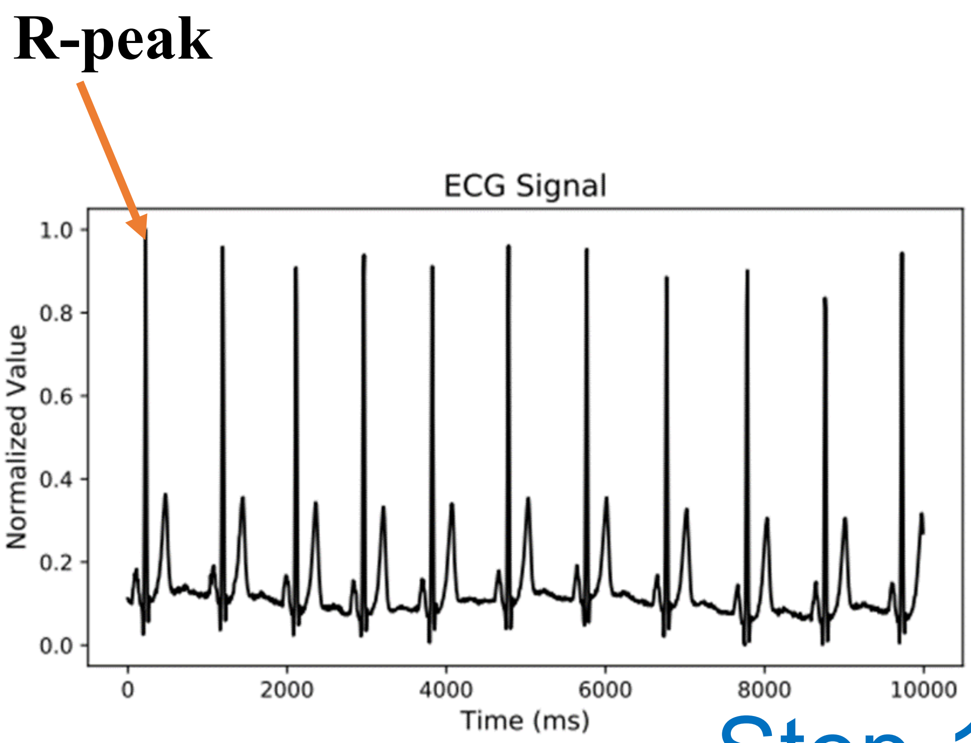
Electrocardiography (ECG) is the process of recording the electrical activity of the heart over a period of time using electrodes placed over the skin.



https://tunedtolife.com/tips-for-medical-professionals-to-get-the-most-out-of-their-ecg-electrodes-and-machines/



https://www.youtube.com/watch?v=ctJM_nhr18A

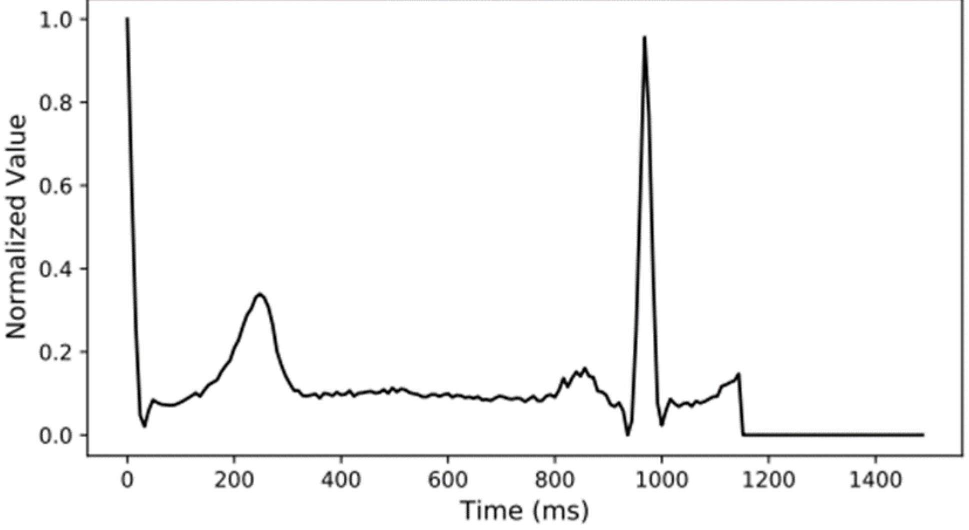


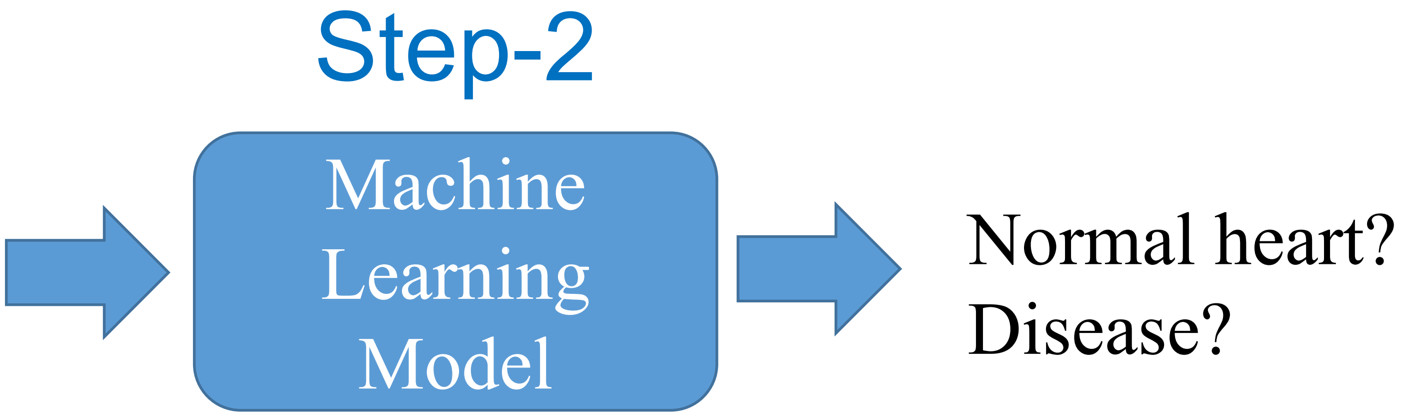
This ECG project has two steps:

step-1: detect the R-peaks,  so that we can extract individual ECG beats

step-2 : build a machine learning model to classify the ECG beats

Step-1





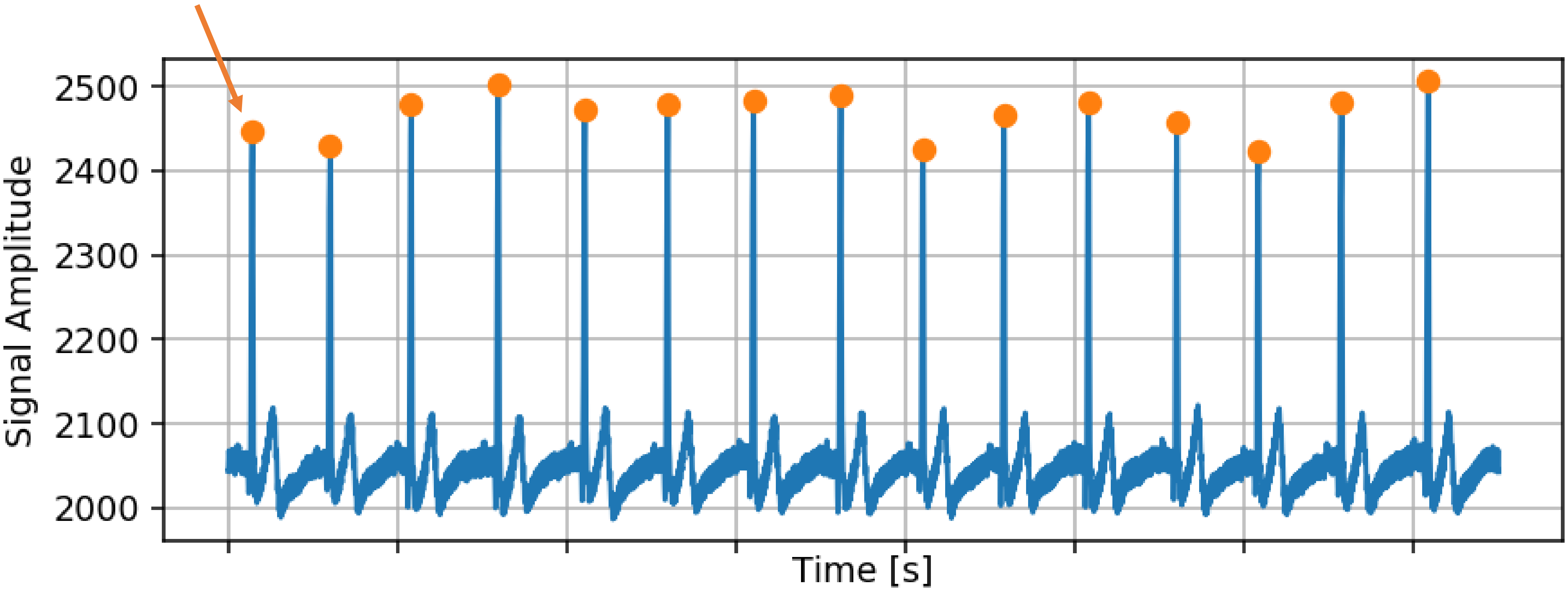
Step-2

Machine Learning Model

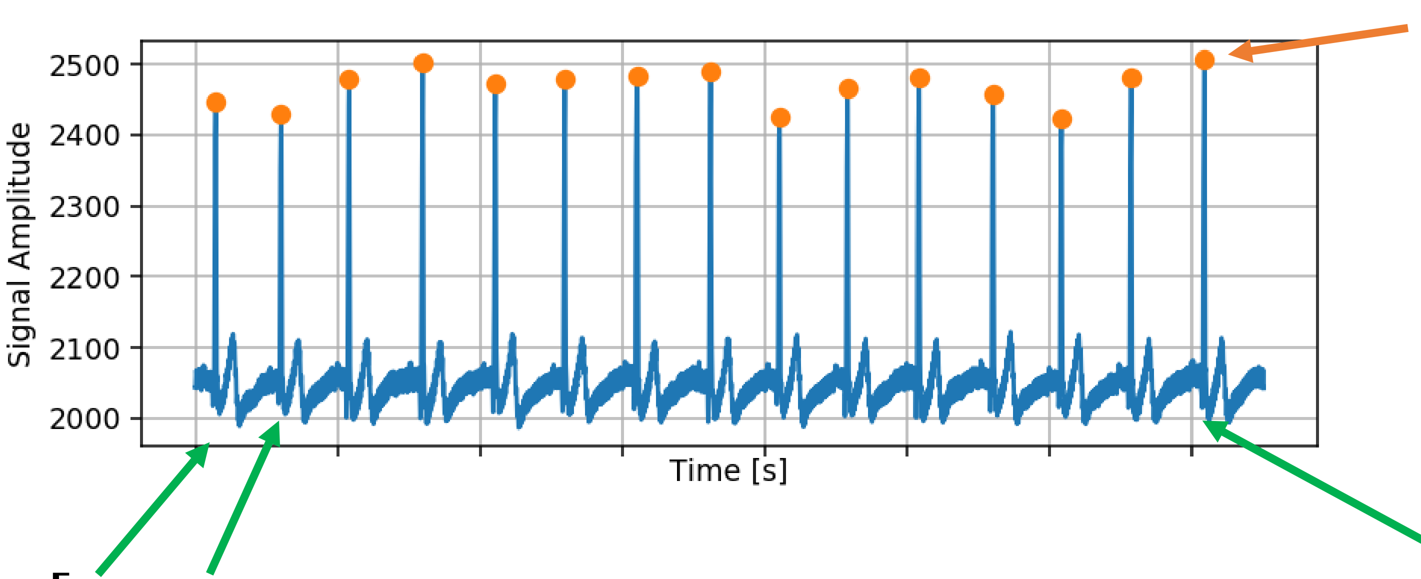
Normal heart?
Disease?

# Step-1: detect the R-peaks

**R-peak**



a R-peak indicates the left ventricle starts to contract



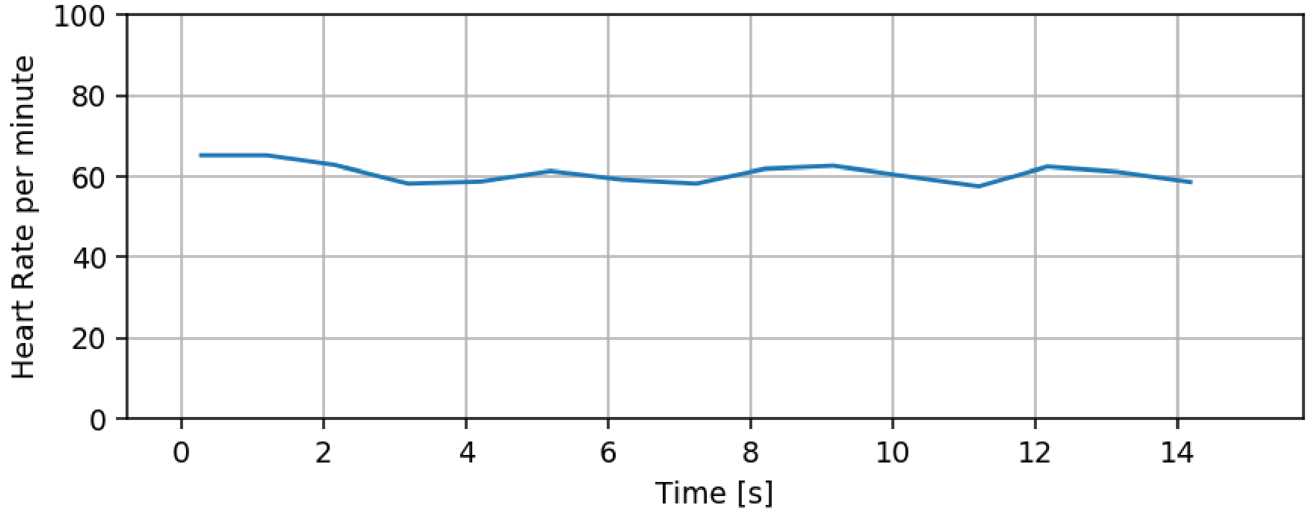
**R-peak**

**From the R-peaks, we can calculate heart rate**

$[t_0, t_1, t_2, t_3, t_4, t_5, t_6, t_7, t_8, t_9, t_{10}, t_{11}, t_{12}, t_{13}, t_{14}]$ a list of time points

$$Heart\ Rate\ Per\ minute\ (t_n)\ = 60/(t_n - t_{n-1})$$

use a numpy array $\{Rate[n]$, n=0,2,…$\}$ to store $Heart\ Rate\ (t_n)$, set $Rate[0]$=$Rate[1]$



# The Algorithm and An Example

- Read 1D_Signal_Processing_Peak_Detection.ipynb

# Algorithm for 1D Signal Peak Detection

Input Signal **x**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $x_0$ | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $x_5$ | $x_6$ | $x_7$ | $x_8$ | $x_9$ |

$\boldsymbol{x_1}$ is a local peak if $\boldsymbol{x_1 - x_0 > 0}$ and $\boldsymbol{x_1 - x_2 > 0}$

two kernels

| | | | |
|---|---|---|---|
| kernel-1 | $-1$ | $1$ | $0$ |
| kernel-2 | $0$ | $1$ | $-1$ |

$\boldsymbol{y_1 = x_1 - x_0}$

Processed Signal **y** using kernel-1

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $y_0$ | $y_1$ | $y_2$ | $y_3$ | $y_4$ | $y_5$ | $y_6$ | $y_7$ | $y_8$ | $y_9$ |

$\boldsymbol{z_1 = x_1 - x_2}$

Processed Signal **z** using kernel-2

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $z_0$ | $z_1$ | $z_2$ | $z_3$ | $z_4$ | $z_5$ | $z_6$ | $z_7$ | $z_8$ | $z_9$ |

if $\boldsymbol{y_1 > 0}$ and $\boldsymbol{z_1 > 0}$ , then $\boldsymbol{x_1}$ is a peak

# Write the Peak Detection Algorithm in Python

```
# x is a signal that has many peaks
h1 = [-1, 1, 0]     # kernel-1
h2 = [0, 1, -1]     # kernel-2
y = scipy.ndimage.correlate(x, h1, mode='nearest')
z = scipy.ndimage.correlate(x, h2, mode='nearest')
```

```
IndexArray1= np.where(y>0)
IndexArray2= np.where(z>0)
```

find the indexes of the positive elements in y

find the indexes of the positive elements in z

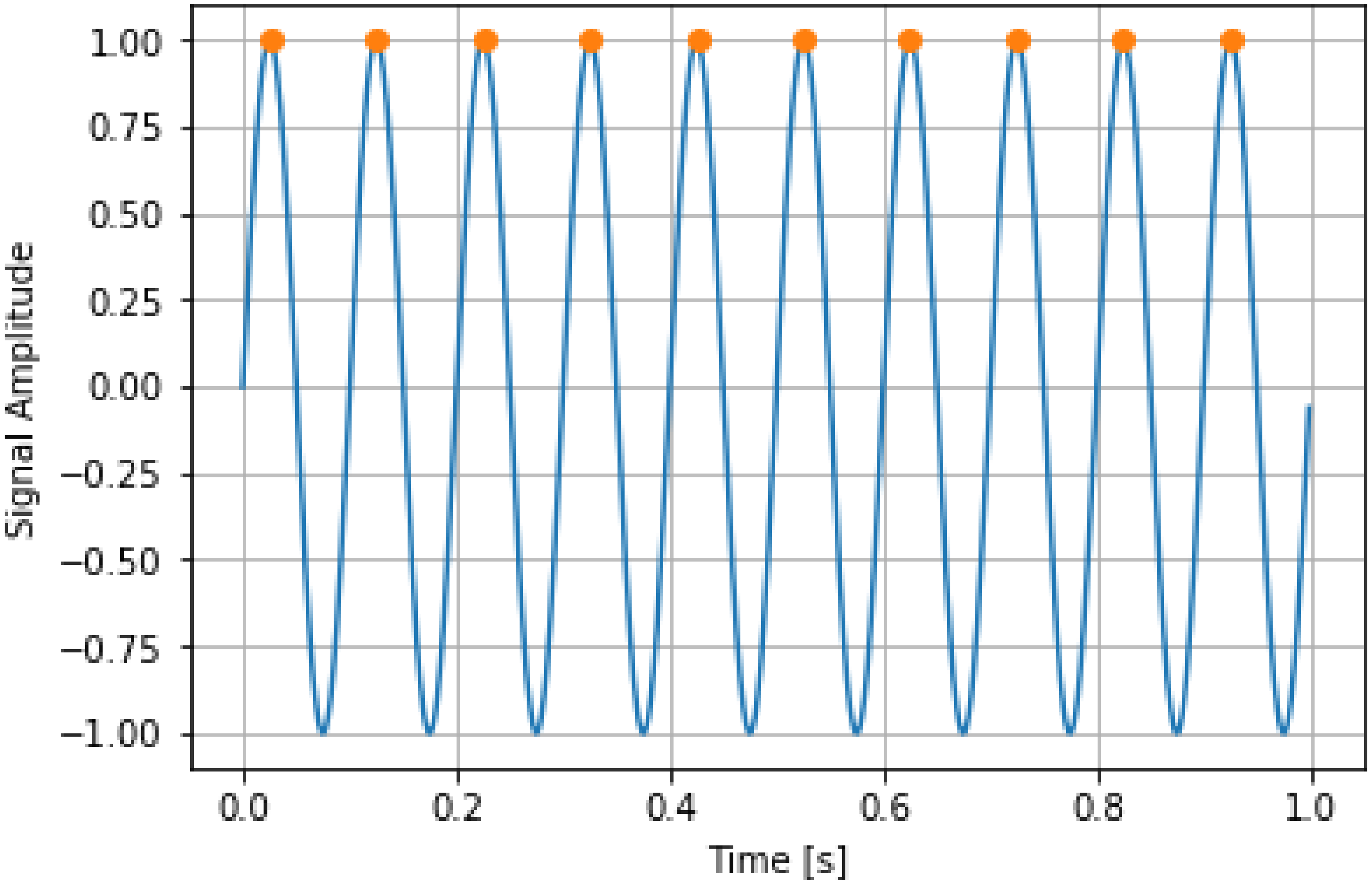
find the intersection of IndexArray1 and IndexArray2 (where y>0 and z>0)

```
PeakIndexArray = np.intersect1d(IndexArray1, IndexArray2)
```

m = PeakIndexArray[n], and m is an element-index of the signal/array x

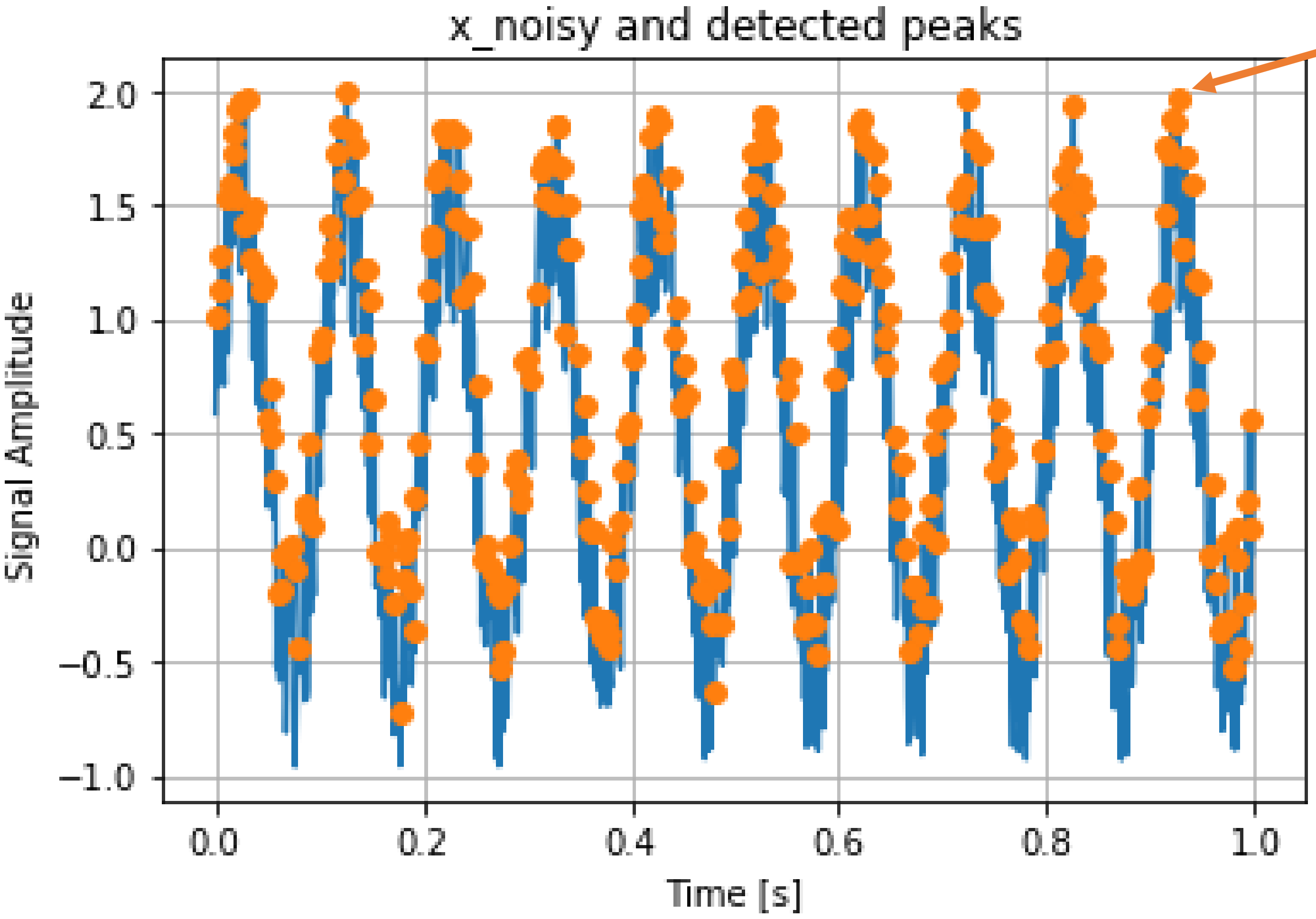
x[m]  is a peak

# Apply the Algorithm to detect peaks of a clean signal



Read 1D_Signal_Processing_Peak_Detection.ipynb

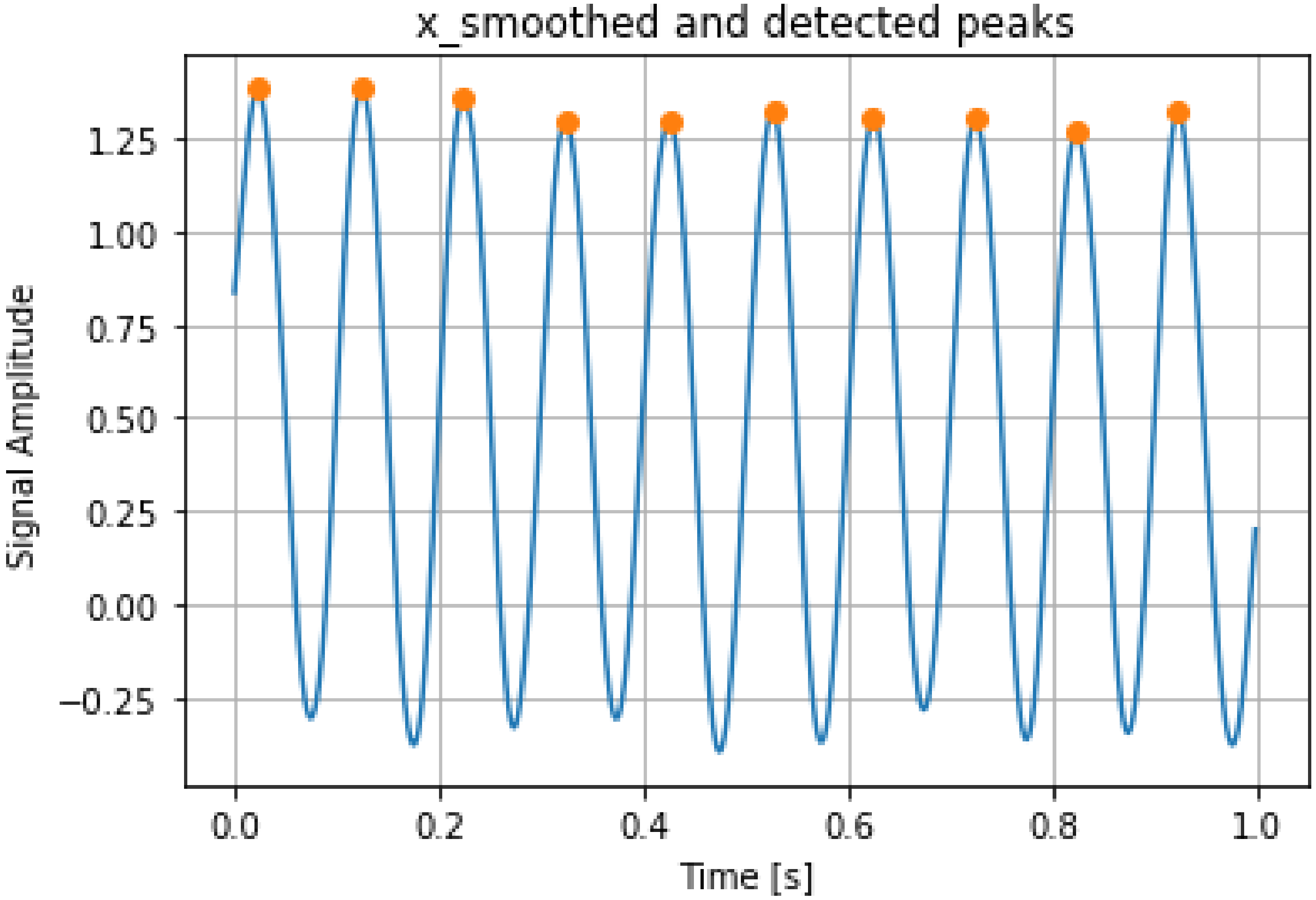
# Apply the Algorithm to detect peaks of a noisy signal



**a Peak**

The algorithm does not work on noisy signals

# Smooth the noisy signal and then detect the peaks



# Your Task

- complete your task in project_ecg_step_1_template.ipynb