Analyzation of the Algorithm:
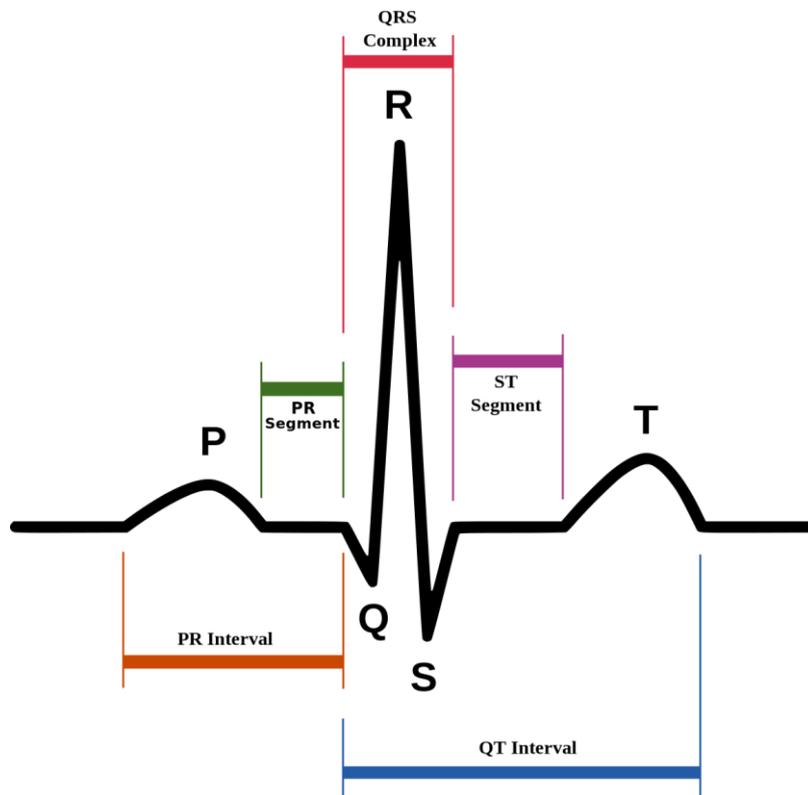

The picture above displays a normal ECG heart beat, this was our starting point for the algorithm.

- R Peak:
  - This is used to calculate all of the other values and is therefore the most important calculation to perform, making this the first thing that we had to calculate
  - It is calculated dynamically within a for loop, meaning that no matter the size of the data, we are able to locate and calculate every single upper peak.
  - The way it works is relatively simple: we loop trough the data and search for the highest value that we find, we log that value and its index in an array, meaning that is our first peak. After that we simply say, skip a certain amount of samples, which we calculate beforehand and then start searching for the next biggest number, aka the next peak in the data set until we find all of the upper peaks.
  - Formula:

```
function calc_R(array)
{
    //calculates R values for QRS
    var newNumber;
    var oldNumber = 0;
    var nextNumber;

    for(var i = 0; i <= (array.length -1); i++)
    {
        newNumber = array[i];
        if(newNumber > r_filter)
```

```
                {
                    if(newNumber > oldNumber)
                    {
                        nextNumber = array[i+3];
                        if(newNumber >= nextNumber)
                        {
                            r_Value.push(newNumber.toFixed(2));
                            r_Index.push(i);
                            i += r_offset;
                            oldNumber = 0;
                            // console.log(i);
                        }
                        else
                        {
                            oldNumber = newNumber;
                        }
                    }
                }
            }
        }
    }
```

- Time per Sample:

    - To calculate the duration of any of the intervals, we need to know what is the time per 1 sample. This is based upon the length of our dataset and the frequency with which our hardware device records the ECG.

    - Formula:

```
var total_time = (array.length - 1) / data.measurement1.frequency;
timePerSample = total_time / (array.length - 1);
```

- Q of each R peak:

    - For the Q value, we look for the lowest point on the left side of the R peak. We do this by pushing the values from the R peak minus a certain offset, till the values of the R peak itself, into a new array. Then to get the lowest value we check with Math.min.apply and push this value and it's index to another array.

    - Formula:

```
function calc_Q(array)
{
    var q_value;
    var q_index;

    for(var i = 0; i < r_Index.length; i++)
    {
        var newArray = [];
        for(var j = (r_Index[i]-qs_offset);j < r_Index[i]; j++)
        {
            newArray.push(array[j]);
        }

        q_value = Math.min.apply(Math,newArray);
        q_index = newArray.indexOf(q_value);
        q_index = q_index + r_Index[i] - qs_offset;

        q_Value.push(q_value.toFixed(2));
        q_Index.push(q_index);
    }
}
```

- S of each R peak:
  - This is done the same as the Q value, with the difference being that we check the right side of the R peak.
  - Formula:

```
function calc_S(array)
{
    var s_value;
    var s_index;

    for(var i = 0; i < r_Index.length; i++)
    {
        var newArray = [];
        for(var j = r_Index[i];j <= (r_Index[i] + qs_offset); j++)
        {
            newArray.push(array[j]);
        }

        s_value = Math.min.apply(Math,newArray);
        s_index = newArray.indexOf(s_value);
        s_index = s_index + r_Index[i];

        s_Value.push(s_value.toFixed(2));
        s_Index.push(s_index);
    }
}
```

- QRS Complex:
  - The QRS complex is the duration between the Q and the S, based on this duration we can make certain statements regarding arrhythmia.
  - Since we have the upper peaks, we can calculate the Q and the S on each side of the R, we do this by checking for the lowest points, left and right of the R peaks. Once we have this we use the distance between the index of Q and S to calculate the QRS complex in seconds.
  - Formula:

```
function calc_QRS_inSec()
{
    //console.log(timePerSample + " sec per sample");
    var qrs_duration;
    for(var i = 0; i < r_Index.length; i++){
        qrs_duration = ((s_Index[i] - q_Index[i]) * timePerSample);
        qrs_Duration.push(qrs_duration.toFixed(2));
    }
}
```

- P Wave:
  - After the QRS complex we need to check if there are any P waves, if there are not, then we have an arrhythmia. If there are P waves we can use the start of the P wave to calculate the PR interval. The start of the P wave is calculated based on where the R peaks are and based on the slope of the curve which indicates a parabola.
  - Formula:

```javascript
function calc_P(array)
{
    for(var index = 1; index < r_Index.length; index++)
    {
        for(var i = (r_Index[index] - p_offset); i < r_Index[index]; i++)
        {
            if(array[i] > (low_filter))
            {
                var slope = (array[(i + slope_offset)] - array[i]) / ((i +
slope_offset) - i);
                //console.log(slope + " index: " + i);
                if(slope > parabola_threshold)
                {
                    p_Wave = true;
                    p_Index.push(i);
                    //console.log(i);
                    break;
                }
            }
        }
    }
}
```

- PR Interval:
  - As mentioned, with the starting point of the P wave we can determine the duration of the PR interval, this is also an important piece of information to determine arrhythmia's. The PR interval is also known as the PQ interval, since it's the duration between the P and the Q value.
  - We calculate this the same way as we did with the QRS complex, take the index of the P value and the index of the Q value and calculate the duration.
  - Formula:

```javascript
function calc_PR_Duration()
{
    var pr_inSec;
    for(var i = 0; i < p_Index.length; i++)
    {
        pr_inSec = (q_Index[(i+1)] - p_Index[i]) * timePerSample;
        pr_Duration.push(pr_inSec.toFixed(2));
    }
}
```

- R-R Interval:
  - The R-R interval is calculated by getting the index from each of the peaks and calculating the distance between them.
  - Formula:

```
•   function calc_RR_interval()
    {
        var rr_interval;
        for(var i = 0; i < (r_Index.length-1); i++){
            rr_interval = ((r_Index[i+1] - r_Index[i]) * timePerSample);
            rr_Interval.push(rr_interval.toFixed(2));
        }
    }
```

- BPM:

    - Since BPM stands for Beats per Minute, this is quite easy to calculate. Based on the sample size of our data and the frequency in Hz, we can check how many R peaks or QRS complexes there are in our sample.

    - So if our sample size is 10000, the frequency is 2500 Hz and there are 5 QRS complexes, then the BPM =

      60 / (10000 / 2500) * 5 = 75 BPM

    - Formula:

```
•   function calc_BPM(array, data)
    {
        var bpm;
        var samples = (array.length - 1);
        var freq = data.measurement1.frequency;
        var amount_QRS = r_Index.length;
        bpm = (secInMin/(samples/freq)) * amount_QRS;
        BPM = Math.floor(bpm);
    }
```

Based on all of these calculations, we set a number of rules on which we were going to determine arrhythmia:

The left box is the value we check and the right box is the corresponding arrhythmia.
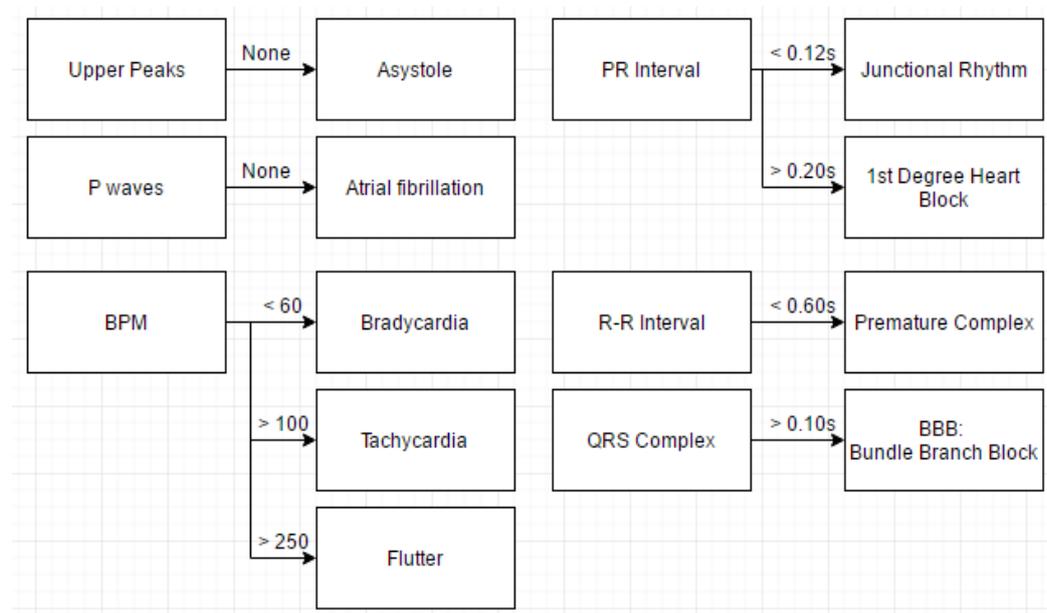
More detailed explanation:

- Asystole:

    - Also known as "Flat Line", there is no measurable heartbeat, or as we calculated this, based on whether there are any R peaks or not. It basically means that the heart is not pumping and therefore there is no blood flow through the body.

- Atrial Fibrillation:

    - If there are no P waves in the ECG strip we speak of Atrial Fibrillation, this originates from the Atriums of the heart, which are the upper chambers of the heart. Atrial Fibrillation is a form of Tachycardia, meaning that the BPM is over 100, in most cases even over 150 BPM.

- BPM:

    - If the BPM is below 60, we speak of Bradycardia, this can both be Atrial or Ventricular, so from either the upper or the lower chambers of the heart.

    - If the BPM is above 100, some say above 120, we speak of Tachycardia, this can also be Atrial or Ventricular.

    - If the BPM is above 250, the arrhythmia is called Flutter, also known as extreme Tachycardia, also here, some papers say it's when the BPM is above 160

- PR Interval:

    - When the PR interval is below 0.12 seconds, we speak of Junctional Rhythm, which is an irregular rhythm that originates from the junction between the atrium and the ventricles, basically the middle of the heart, therefore it's called junctional.

    - When it is above 0.20 seconds, we speak of a 1st degree Heart Block.

- R-R interval:

    - Known as PVC or PAC, the premature Complex can also both be ventricular or atrial based. In some cases the heartbeat after the premature complex can be very forceful, leading to a short pain in the chest. This is caused, when either the upper or the lower chambers of the heart, contract faster than the rest of the heart. The Premature Complex is the most common Arrhythmia. We can determine this based on the R-R interval, more specifically when this is interval is very short.

- QRS complex:

    - When the QRS complex is wider than 0.10 seconds, we speak of the triple B, Bundle Branch Block. This is a defect in the muscle fibres of the heart.

Sources:

https://www.cardionetics.com/introduction-to-the-ecg

http://www.medicalnewstoday.com/articles/8887.php

http://www.meddean.luc.edu/lumen/meded/medicine/skills/ekg/les1prnt.htm

https://courses.kcumb.edu/physio/ecg%20primer/normecgcalcs.htm

https://www.practicalclinicalskills.com/ekg-reference-guide

https://www.nurseslearning.com/courses/nrp/nrp1619/section%203/index.htm

https://nl.ecgpedia.org/wiki/Grondbeginselen

http://emedicine.medscape.com/article/2172196-overview

https://en.wikipedia.org/wiki/PR_interval

http://www.mauvila.com/ECG/ecg_fundamentals.htm

http://article.sapub.org/10.5923.j.ijbe.20120205.02.html

Videos:

https://www.youtube.com/watch?v=rsWnFv62Ie8

https://www.youtube.com/watch?v=PYX5oZCSTAY&feature=youtu.be