Final Report DASU20 Group 9

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1. INTRODUCTION

This final report consists of 3 assignments. In the first assignment, we learned about the different runner profiles by analyzing 5 runners and assigning them one of the profiles [32]. In the second assignment, we analyzed a real-time data set. By using python to explore the data, we were able to assess the performance of the runner. Assignments 1 and 2 were used as preparation assignments for the final assignment, assignment 3. In the first part of the assignment 5 runners were analyzed and put into one of the runner profiles, which helped us decide on the group running profile. In the second part of the assignment, we analyzed the training sessions of one of the runners. Based on this data, we created an app which allows the runner and his team mates to give each other feedback, tips, and exchange tactics. This will help the runners learn from each other and ultimately improve their running performance.

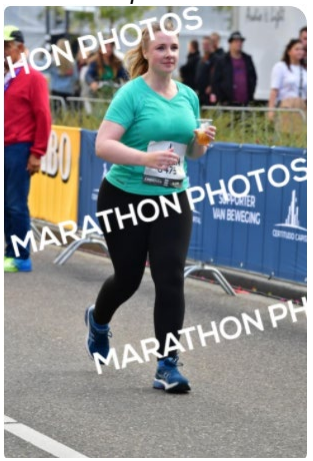
2. ASSIGNMENT 1 – EINDHOVEN MARATHON ANALYSIS

2.1 Introduction

In this assignment 5 random users who took part in the Eindhoven half marathon in 2021, were analyzed. The users had to be recreational runners with a time of 2 hours and 15 minutes or longer. In this assignment the participants were first analyzed individually and at the end the participants were compared to form a conclusion based on the found data.

2.2 Analysis participants

2.2.1 Participant 1



Chip Time
02:54:15
Description
Irish Female
Category
V40 (female aged between 40-44 years old)
Pace
08:15 min/km [18]
Equipment
Asics Running shoes
Clothes
Mint sports shirt Black legging
Additional Comments
Looks like she is drinking beer while running. Hair in ponytail.
Performance
In the beginning, she starts off relatively fast compared to the rest of the marathon. The first 5 km she runs an average of 7:25 min/km. In the middle sector of the marathon, her pace is fairly consistent between 08:04 min/km and 08:19 min/km. At the finish, her pace drops to 09:04 min/km [18]. Objectively looking, she did not do very well. However, considering that she ran for charity and finished the marathon, she probably reached her personal goal.
Runner profile
Social runner: Participant 1 can be described as a social runner since she runs marathons to raise money for charity [29].

2.2.2 Participant 2

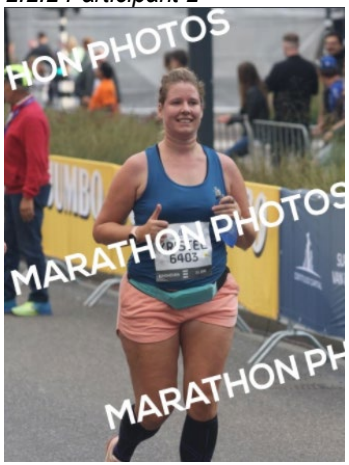


Figure 2: Participant 2 [10]

Chip Time
02:38:15
Description
Belgian Female
Category
V35 (Female aged between 35-39 years old)
Pace
7:30 min/km [20]
Equipment
Smartwatch Foldable water bottle (in her hand) Pink Asics running shoes
Clothes
Blue tank top Pink shorts Stox black running compression socks Turquoise fanny pack (with phone inside)
Additional Comments
Thumbs up on all the pictures Smiling in all the pictures Hair in ponytail
Participant is running together with a friend
Performance
Runs faster in the first 5 km (7:04 min/km) [20]. After the first 5 km she slows down a bit and then continues the rest of the marathon in about the same pace (average of 7:38 min/km) [20]. Looking at the fact that participant 2 is not in the best physical shape and she is running together with her friend, one can say that she did quite a good job timewise. Overall, she also kept around the same pace and did not slow down a lot compared to other analyzed runners of this assignment. Participant 2 slowed down 40 seconds overtime in her pace [20], while participant 3 slowed down more than 2 minutes in his pace [17] and participant 4 slowed down 5 minutes in his pace over time [16]. So objectively looking runner 2 did a great job keeping around the same pace, which is important while running a marathon.
Runner profile
Social runner: Participant 2 can be profiled as a social runner, since she is running the marathon together with a friend of hers. On the pictures it is seen that she is having fun and talking with her friend while running. The Instagram of the participant shows that she runs with this particular friend more often [30]. The friend she is running with also posted a picture of the two of them together with their medal of the marathon [25]. From this post it can be concluded that they are happy and proud to have finished the marathon.

2.2.3 Participant 3

Figure 3: Participant 3 [7]

Chip Time
02:59:00
Description
German Male
Category
Msen (Male aged below 40)
Pace
8:29 min/km [17]
Equipment
Running watch Wrist bag Black Asics sneakers
Clothes
Blue ASML shirt Black Adidas shorts Grey socks
Additional Comments
Runner looks happy
Performance
Participant 3 finished second last of all the runners. So objectively looking the performance was not that good. He started reasonable at a pace of 7:12 min/km, but he slowed down a lot as the race continued. The last 6.1 km he ran at a pace of 9:36 min/km [17].
Runner profile
Individual fitness runner: Participant 3 can be described as an individual fitness runner, since he is running by himself.

2.2.4 Participant 4

Chip Time
02:55:58
Description
Dutch Male
Category
Msen (Male aged below 40)
Pace
8.20 min/km [16]
Equipment
Joma indoor soccer shoes In-ear headphones Smartphone
Clothes
Black Adidas shirt Black Adidas shorts
Additional Comments
Both the clothes and shoes have the purpose of playing soccer in it and not so much running. In various pictures he looks very tired, and his feet seem to be hurting.
Performance
Participant 4 started off all right, finishing the first 15 km in just 1:36:09 hours. However, after that his speed decreased, and it took him 1:19:49 hours to finish the final 6.1 km [16]. Objectively looking, he did not do well. However, considering that he ran for charity and finished the marathon, he probably reached his personal goal.
Runner profile
Social runner: Participant 4 can be described as a social runner since he ran the marathon to raise money for charity [3].

Figure 5: Participant 5 [12]

Chip Time
02:58:23
Description
Indian Male
Category
M40 (Male aged between 40-44 years old)
Pace
8.27min/km [22]
Equipment
Smartwatch, In-ear headphones On Cloudstratus running shoes
Clothes
Adidas Shorts Artengo sport shirt Stox compression socks
Additional Comments
Participant 5 seems very happy that the finish line is in sight. It looks like he is running individually.
Performance
Participant 5 runs at a pace of 7:50 min/km in the first 5 km and gradually slows down to 8:52 min/km [22]. The way he ran at the end of the 21 km may indicate that he gave all the energy that he had left to finish. Based on his physical looks and facial expressions, one could say he did well. However, it was not the first time he participated in the half marathon of Eindhoven. He also participated in 2018 [28]. Finishing as one of the last participants in 2021 is therefore not a great performance.
Runner profile
Individual fitness runner: Participant 5 can be described as an individual fitness runner, since he does not run with someone else.

2.3 Conclusion

We have found qualitative data as well as quantitative data. Via the data, such as their pace and chip time, we could make assumptions and conclusions. How the pace of the participants changed over time, for example. This gave good insights into how well the participants arranged their race, if they started too fast or if they were able to keep the same pace during the race, for example. By using the photos (qualitative data) we were able to make assumptions. Using this qualitative data, we could make statements about the clothes they were wearing, for example. From this data we could conclude that one of the participants, participant 4, did not wear the proper clothes to run half a marathon. This stood out, because the other participants were all wearing running shoes and running clothes, while participant 4 wore soccer shoes and clothes. In the end we were able to conclude if the participants did a good job. We concluded that not all participants did equally well, in terms of how much their pace changed. However, we do think that for these participants their personal goals were reached, running and finishing the half marathon of Eindhoven.

3. ASSIGNMENT 2 – ANALYSE A REALTIME DATASET

3.1 Introduction

In this assignment a real-time dataset was analyzed. The dataset that was analyzed is from a runner who ran a route of 42,9 km. To start analyzing the GPX file first had to be converted to a CSV file, in order to open it in Excel and Python. When this was done the CSV file could be opened in Excel and Python. For this assignment we chose to work with Python, since we found it easier to clean and visualize the data in Python. For this assignment, the dataset was cleaned, analyzed, and visualized, in order to analyze the performance of the runner.

3.2 Questions

3.2.1 Analyze a real time detailed dataset; what can you learn from it?

The detailed real-time dataset contained a lot of data. In fact, there was so much data that we needed to structure and visualize the data in order to be able to analyze it. There were also outliers in the dataset. That is why we needed to clean the data first, before we could analyze it.

3.2.2 How can we support individual runners given their real-time performance?

It may be difficult to support one individual runner based on the data of only one run. If you have access to the data of multiple runs you can find out if the runner is heading in the right direction. With the given data you will be able to set up the best possible workouts to improve their run.

3.2.3 What software can you use to open a GPX file?

Bikemap and Routeyou are examples of GPX systems that show the route ran by the runner. In both systems you can see the route run by the person.

In Bikemap (fig. 6) you can quickly see the information on the right side of the map. Next to the information about the run, points of interest can be added to your route. Apart from that there is not much more information about the route and performance.

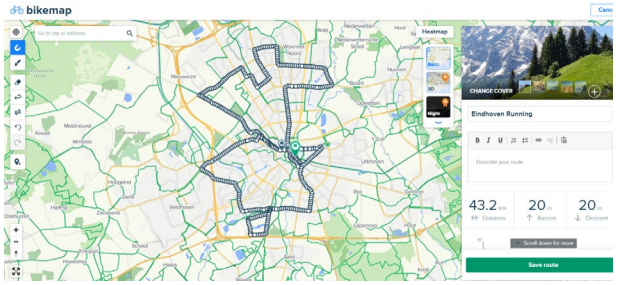


Figure 6: Route shown in Bikemap [1]

In Routeyou (fig. 7) you can find a lot of information about the run. Next to numerical values the information is also presented in visuals. You can also find information about points of interest along the route such as buildings and places to eat and drink (fig. 8). You can quickly find new routes near the one you run.

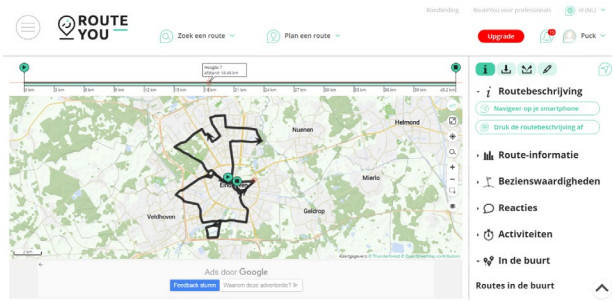


Figure 7: Route shown in RouteYou [31]

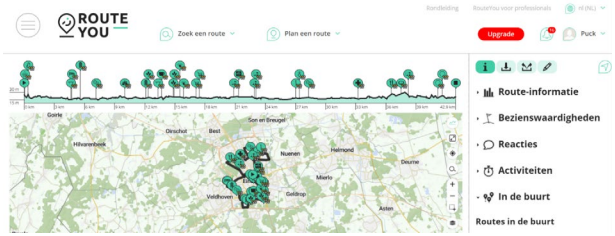


Figure 8: Route shown in RoutYou with sights [31]

Excel, Python and Tableau are software that can be used to clean, analyze, and visualize the data of the dataset. To be able to open the GPX file in these software, the GPX file first needs to be converted to a CSV file. This can be done by an online converter, RouteConverter [26] for example.

With Excel it is hard to clean the data and it is difficult to find a value in a certain column (fig. 9). This will make it harder to analyze the run and determine if the performance is good or not. With python it is easier to clean and visualize the data, and therefore it is easier to analyze the run.

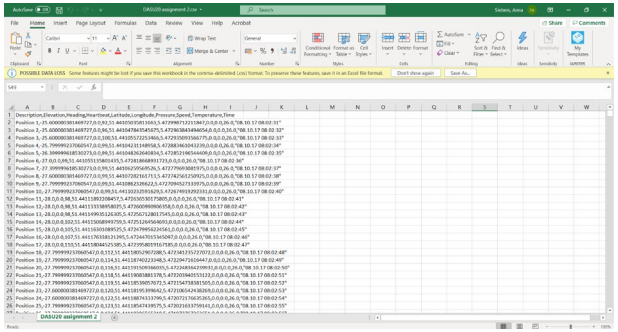


Figure 9: Data set opened in Excel

3.2.4 What data contains a GPX file? How is this data structured? How can I use this for assignment 3?

A GPX file contains many different data such as elevation, heading, heartbeat, latitude, longitude, pressure, speed, temperature, and time (fig. 10). With latitude and longitude values you can determine the location of the runner and thus the distance covered by the runner. With this data, we can analyze the run and judge whether it was a good run or not. This can depend on the speed of the runner, but it can also depend on the heartbeat of the runner.

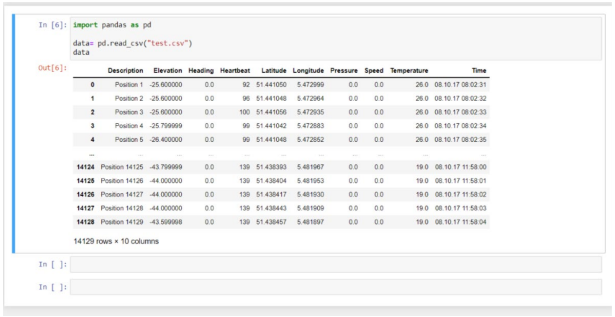


Figure 10: Data set opened in Python

3.2.5 How much do I need to "clean" this data before I can use it?

The dataset was all set to be used. However, the speed shown at first was zero. To get the actual speed ran by the runner, we needed to calculate the distance ran by the runner from position 1 to position 2, etc. When we got this distance, we were able to calculate the speed of the runner using the time. By making a plot we could see that there were a few outliers in the speed (fig. 11) therefore we cleaned the data (fig. 12). For the other values such as heartbeat (fig. 13), elevation (fig. 14), latitude (fig. 15) and longitude (fig. 16) we did not need to clean the data.

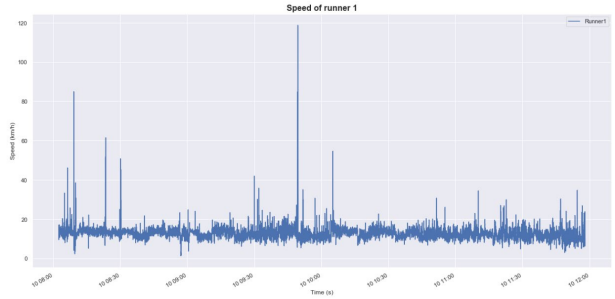


Figure 11: Speed of the runner with outliers

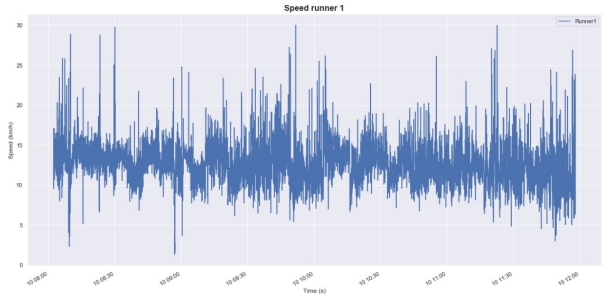


Figure 12: Speed of the runner with cleaned data

Figure 13: Heartbeat of the runner

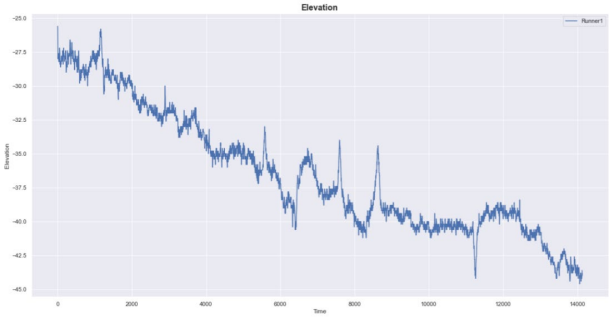


Figure 14: Elevation during the run

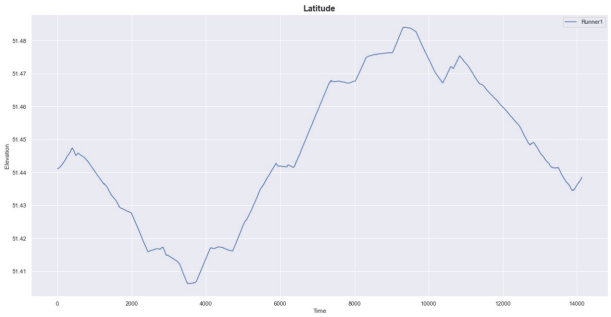


Figure 15: Latitude value during the run

Figure 16: Longitude value during the run

3.2.6 Can I already analyze this run? Was it a good run or are there points for improvement?

Because the graph was still unclear to analyze, we applied a gaussian filter to the data (fig. 17). The black line makes it easier to see what the speed of the runner was during the run.

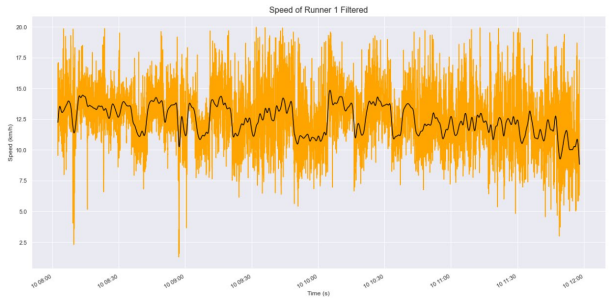


Figure 17: Speed of runner 1 with gaussian filter

De graph shows that the speed fluctuated between 11km/h and 14.5 km/h. In other words, the speed was not constant during the run. An improvement point for the runner would be to maintain a constant speed throughout the run. Also, the heartbeat is not constant during the run, so the runner could pay attention to this during training.

3.3 Conclusion

In this assignment we analyzed a real-time dataset. From this dataset we learned that it is important to first clean the data (remove outliers) in order to be able to analyses the data. Visualizations helped us to get a clear idea of what the information in the dataset meaned. It allowed us to identify outliers and gain insights into the performance of the runner.

4. ASSIGNMENT 3 – TEAM RUNNING IN TIMES OF COVID-19

4.1 Introduction

In this assignment, data was used as a mean to motivate a team of runners. This team would normally train together, but due to the Covid pandemic the possibilities to train together as a team were limited and unpredictable.

For the first part of this assignment, 5 runners who took part in the Eindhoven half marathon in 2021 were analyzed. The runners belonged to the same team. The 5 runners were first analyzed individually, after which the runners were analyzed as a group, to find the runner profile of the DASU20 team.

For the second part of the assignment actual data of one of the runner's preparations was analyzed. This data was visualized in order to give the other team members an idea of the progress of the runner. So, the team members are aware of the progression of the runner and can support the runner with its training.

After both parts of the assignment enough information was collected, to form conclusions based on the data found.

4.2 Analysis runners

To analyze the 5 different runners, the data of the real datasets were analyzed as well as the photos and videos made during the marathon. In order to be able to use the real datasets, the first step was to clean the data. This was done by removing the outliers from the data sets. Then, the average speed of the runners was determined and compared with the values on the website. In this way it was possible to see which data set belonged to which runner.

Next, the data was plotted in line graphs. A gaussian filter was applied to the speed to make the graph smoother and easier to read. With this information the performances of the runners were analyzed. To further analyze the runners, the runners are put into one of the four different runner profiles [32], based on their performance and looks.

Table 1: Characteristics of four different types of runners [33]

Characteristics	Social competitive runners	Individual fitness runners	Individual competitive runners	Social runners
Main driver	Competition	Health	Performance	Running together
Main running context	Sports club	Individual	Individual	Running community/friends
Intensity	High	Low / moderate	High	Low
Ease of practice	Low	High	High	Low
Perceived advantages of running	Moderate	High	High	Moderate
Individual motives for quitting	Low	High	High	Moderate/high
Social motives for quitting	High	Low	Low	High

4.2.1 Runner 1

Figure 18: Runner 1 [5]

Chip Time
01:56:52
Description
Dutch Male
Category
M60 (male aged between 60-64 years old)
Pace
05:32 min/km [15]
Equipment
Fanny pack Sports watch Black running shoes
Clothes
Red sports singlet (same as runner 5) Black short running tights
Additional Comments
He looks exhausted in most pictures.
Performance
His speed is very constant when looking at the MYLAPS results. His speed between 10 and 15 kilometer was the highest, at 05:33 min/km [15].

When looking at the graph of the speed from the whole marathon it is a different story. The speed fluctuates a lot, sometimes he runs at 20 km/h and other times he walks at 6 km/h. However his average speed remains fairly constant throughout the marathon, especially in the second half.

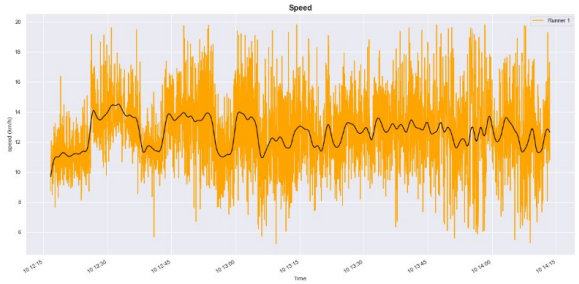


Figure 19: Speed runner 1

The graph below shows the heart rate of runner 1. Out of the graph one can say that the heart rate of the runner fluctuates quite a lot, between 155 and 180 bpm.

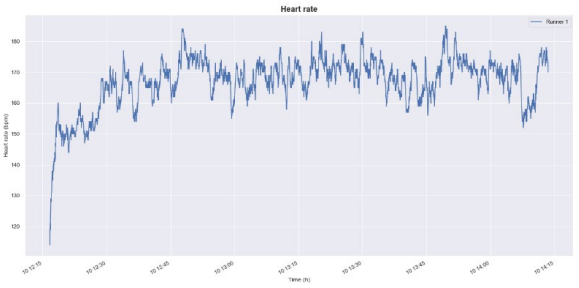


Figure 20: Heart rate runner 1

Looking at the fact that the speed and heart rate of runner 1 fluctuate quite a lot during the marathon, one can say that the runner still needs to improve its running.

Runner profile
Individual fitness runner: Runner 1 runs alone, so we see him as an individual runner. When looking at his heart rate, we can see it fluctuates a lot. Also, when looking at his average speed at 10,83 km/h [15], we can conclude it is not a competitive runner. So that makes him an individual fitness runner.

4.2.2 Runner 2

Figure 21: Runner 2 [9]

Chip Time
01:35:57
Description
Chinese Male
Category
M50 (male aged between 50-54 years old)
Pace
04:33 min/km [19]
Equipment
Nike running shoes Smart watch Sweatband Sunglasses

Clothes
Red TU/e sports shirt Blue shorts
Additional Comments
Still looks like he has energy left even though he can already see the finish.
Performance
His average speed is quite constant. The average pace of the first 15 kilometers is between 4.27 min/km and 4.33 min/km [19]. However, on the graph you can see that in the beginning the speed fluctuates and towards the end of the run the speed remains more constant. In the last 6 kilometers, the average tempo has increased, but not by much. At the end, the average pace is 4.40 min/km [19].

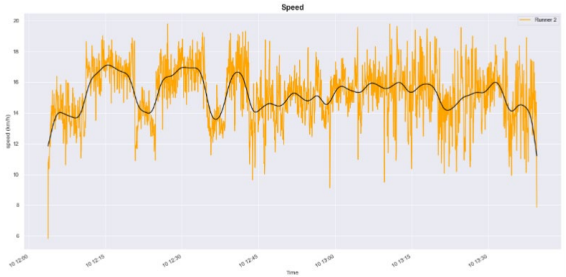


Figure 22: Speed runner 2

In the graph below you can see you can see that the heart rate of runner 2 is quite constant, with some outliers.

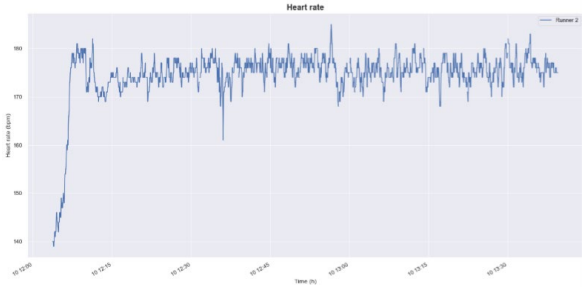


Figure 23: Heart rate runner 2

Looking at the fact that runner 2 keeps quite a constant speed and a constant heart rate, one can say that he did an excellent job running the half marathon.
Runner profile
Individual competitive runner: Runner 2 is running alone. It can be assumed he is an experienced runner as his heart rate and speed remain constant throughout the run. He also finished 81st which is high considering 551 people took part in this run [19].

4.2.3 Runner 3

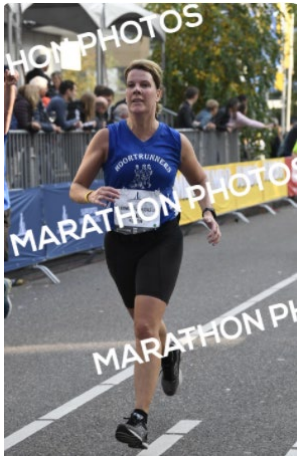


Figure 24: Runner 3 [11]

Chip Time
01:59:32
Description
Dutch Female
Category
V45 (female aged between 45-49 years old)
Pace
05:40 min/km [21]

Equipment
Smartwatch Black running shoes
Clothes
Blue sports singlet Black short running tights
Additional Comments
-
Performance
Her speed is quite consistent during the first 15 kilometers and drops at the end. During the last 6.1 kilometers her speed drops from 5:35 min/km to 5:54 min/km [21].

Figure 25: Speed runner 3

The graph below shows the heart rate of runner 3. Out of the graph one can see that her heart rate rises in the last 45 minutes from around 160 bpm to a little above 180 bpm.

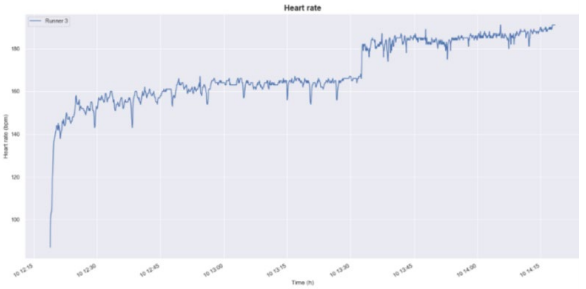


Figure 26: Heart rate runner 3

Looking at the fact that the speed and heart rate of runner 3 changed during the last 45 minutes, one can say that the runner still needs to improve on keeping consistent throughout the whole race.
Runner profile
Individual fitness runner: Runner 3 is running alone, which means that she can be considered an individual competitive runner or an individual fitness runner. She finished 411th out of 551 and had an average speed of 10.59 km/h [21]. Therefore, she cannot be considered an individual competitive runner. So, she can be described as an individual fitness runner.

4.2.4 Runner 4

Figure 27: Runner 4 [13]

Chip Time
01:56:33
Description
Dutch Male
Category
M50 (male aged between 50-54 years old)

Pace
05:31 min/km [23]
Equipment
Smartwatch Backpack with water tube Black Nike Pegasus running shoes
Clothes
Red sports shirt Black shorts
Additional Comments
Looks happy and relieved to see the finish.
Performance
His speed is quite constant. Starts out a bit faster in the first 5 kilometers, with a pace of 5:19 min/km [23]. After the first 5 kilometers, his speed decreases a little bit to 5:33 min/km. He keeps around this pace (5:33 min/km-5:39 min/km) during the rest of the marathon. However, on the graph you can see that in the beginning the speed changes quite drastically and towards the end of the run the speed remains more constant.

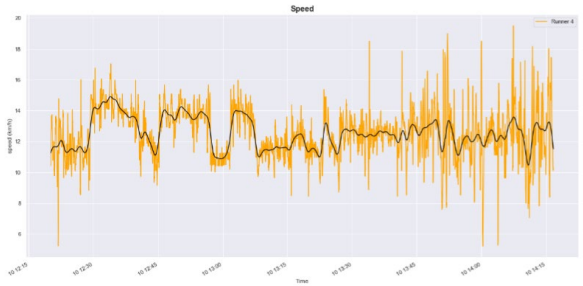


Figure 28: Speed runner 4

Runner 4 keeps a constant heart rate throughout the marathon, as seen in the graph below.

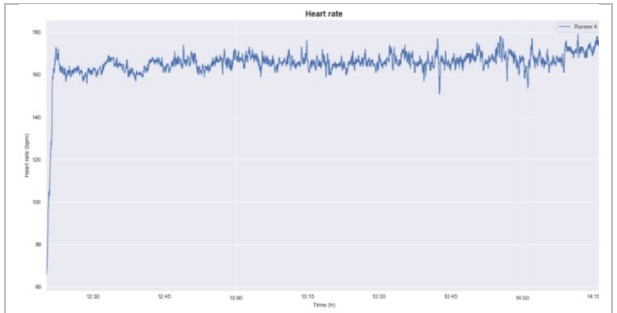


Figure 29: Heart rate runner 4 '

Looking at the fact that runner 4 keeps a constant heart rate, one can say that he did a good job running the half marathon. Although runner 4 can still improve on keeping a consistent speed throughout the race.

Runner profile
Individual fitness runner: Runner 4 is running alone which would mean he could be described as an individual fitness runner or an individual competitive runner. But since he finished 385th out of 551 runners and his average speed is 10.86 km/h [23], he cannot be considered an individual competitive runner. So, runner 4 can be described as an individual fitness runner.

4.2.5 Runner 5

Figure 30: Runner 5 [14]

Chip Time
01:43:24
Description
Dutch Male
Category
M50 (male aged between 50-54 years old)
Pace
04:54 min/km [24]
Equipment
Sports watch Saucony Ride Iso 2 running shoes
Clothes
Red sports singlet Grey short running tights
Additional Comments
He does not seem exhausted.
Performance
He has a very constant speed, average of 12.24 km/h that only varies within a range of 0.3 km/h [24]. He slows down a little between the 10th and 15th kilometer but manages to speed up again until he crosses the finish. The graph also shows that the runner keeps a consistent pace throughout the marathon.

Figure 31: Speed runner 5

The heart rate of runner 5 does fluctuate a lot during the marathon, as seen in the graph below.

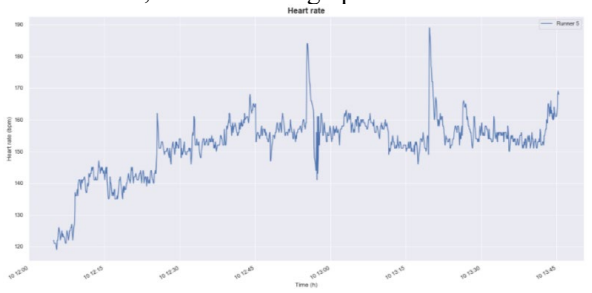


Figure 32: Heart rate runner 5

Looking at the fact that runner 5 keeps a constant pace, one can say that he did a good job running the half marathon. Although runner 5 can still improve by keeping a consistent heart rate throughout the race.

Runner profile
Individual competitive runner: Runner 5 is running alone. Therefore, he could be described as an individual fitness runner or an individual competitive runner. The graphs of his run show that his speed is quite constant and, except for some peaks. He finished 150th out of 551 runners and his average pace is 4.54 min/km time [24], so he can be considered an individual competitive runner.

4.2.6 DASU20 Team profile

All 5 runners have 3 significant peaks in their speed at the beginning of the run (fig. 35). These can be explained by the fact that there are care points at these parts of the race (fig. 33 & 34). At these points, several runners will slow down, causing the whole group to slow down in their speed. The reason we only find these peaks only in the beginning of the run, is because of the group size. Further into the race, people will spread out and the fast runners will be ahead. At the care points further in the race it will be less crowded and not everyone will have to slow down to pass these points.

Figure: 33: Route combined with speed

Figure 34: Route half marathon Eindhoven 2021 []

After analyzing all five members of the DASU20 team, we found that 3 runners; runners 1,3 and 4; can be considered as individual fitness runners. We also found that 2 runners; runner 2 and 5; can be considered individual competitive runners. This distinction between the two types of runners; individual fitness runner and individual competitive runner; is based on the speed of the runners as well as the heart rate of the runners. To decide the runner profiles of the runners, we looked at whether the speed of runners was constant, and whether the heart rate of the runners was constant throughout the marathon. As seen in the graph below the speed of runner 2 (yellow line) and runner 5 (purple line) were significantly higher than the speed of the three other runners. This can also be seen in the results of the marathon (fig. 36), where runner 2 finishes 21 minutes before runner 1 and runner 5 finishes 13 minutes before runner 1. Runner 1, 4 and 3 all finish within a period of 5 minutes of each other (fig. 36).

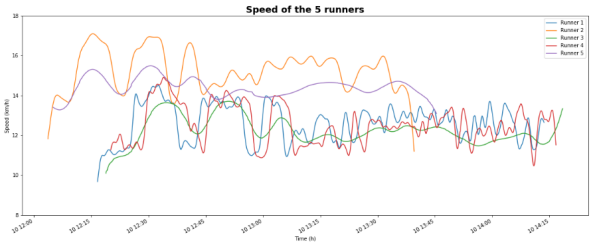


Figure 35: Speed of the 5 runners

DASU20 1

POS 45 **SCORE 05:15:54**

POS	NAAM	BIB	CATEGORIE	BRUTO TIJD	NETTO TIJD	SCORE
81	Runner 2	40310	M50	01:39:26	01:35:57	01:35:57
150	Runner 5	40306	M50	01:45:21	01:43:24	01:43:24
331	Runner 1	40307	M60	01:58:31	01:56:52	
385	Runner 4	40308	M50	02:01:40	01:56:33	01:56:33
411	Runner 3	40309	V45	02:03:24	01:59:32	

Figure 36: Results team DASU20

The graphs below confirm the facts that runners 2 and 5 are faster than runners 1,3 and 4 and that runners 2 and 5 have a more constant heart rate than runners 1,3 and 4. As shown in figure 37, the average speed (green star) of runners 2 and 5 are higher than the average speed of the three other runners. Next to that the speed of runners 2 and 5 is also more constant, compared to runners 1, 3 and 4. This can be seen in figure 35 as well as in figure 37. In figure 37 the minimum and maximum speed of runners 2 and 5 differ not as much as the intervals of the other three runners. Figure 35 also shows that runner 5 has the most constant speed, see the purple line. The speed of runner 2 however fluctuates, especially in the beginning, see the yellow line. Figure 35 also shows that runner 3 also has quite a constant speed, which is important while running.

Figure 38 shows the heart rate of the 5 runners. Out of figure 38 we can conclude that runners 2 and 5 have a more constant heart rate than runners 1, 3 and 4. This can be concluded, since the difference between the minimum and maximum heart rate of runners 2 and 5 is smaller, compared to the intervals of the three other runners. The figure also shows that runner 5 has the lowest average heart rate, out of all runners. However, in the individual runner evaluation, one can see that runners 2 and 4 have a very constant heart rate and heart rates of runners 1,3 and 5 fluctuate during the race.

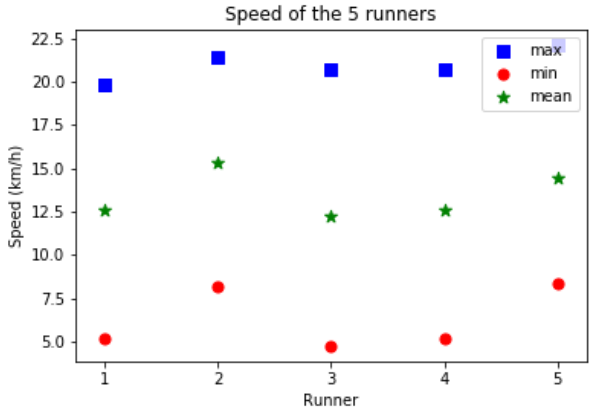


Figure 37: Speed of the 5 runners

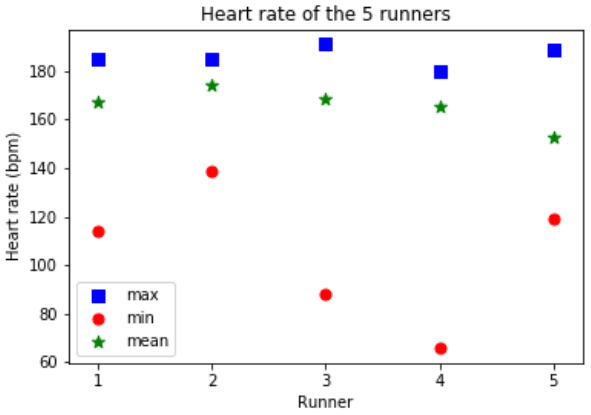


Figure 38: Heart rate of the 5 runners.

Evaluating, analyzing and comparing the individual results leads to the fact that 3 runners; runners 1,3 and 4; can be considered individual fitness runners and 2 runners; runner 2 and 5; can be considered individual competitive runners. Looking at the facts as speed and heart rate and the consistency of speed and heart rate, where some runners have to improve on their consistency of speed and others of heart rate, one can say the DASU20 team can be given the profile of individual fitness runners.

4.3 Analysis training runner 1

For this part of the assignment, we analyzed different data sets of training runs of runner 1. This analyzation was done in order to create a clear overview of the preparation done by runner 1 for the half marathon. First a quick analysis was done of the preparation runs, to look for patterns and running tactics. Later the analyzation of runner 1's preparation was visualized, so that his teammates can get an overview of the progress of runner 1.

The visualization also makes it possible for the teammates to give runner 1 tips on how to improve his running and support him with his running. Next to that the visualization can also be used as a learning opportunity for the runners. So, they can learn from each other's running tactics and see which tactics can best be used to prepare for a race.

4.3.1 Analysis

To analyze the training runs of runner 1 the runs were first put into a RouteYou [27], to show the route ran by runner 1 as well as the distance ran by runner 1. After that each training session was analyzed individually, by looking at the speed and heart rate of runner 1. Based on these insights we were able to analyze every training and categorize them into different categories. For example, if it was a long or short run, or if it was an interval training for example. We came up with five different categories: short run, medium run, long run, interval and race. Where a short run would be a run shorter than 7 km, a medium run would be a run between 7 and 15 km and a long run would be a run longer than 15 km.

Besides the kind of run it was, we also looked at the speed and heart rate fluctuations. When runner 1 had a constant speed, we looked to see if the heart rate of runner 1 was also constant, for example. We also looked if speed changes were connected to heart rate changes. So, when the speed decreased, we looked if the heart rate also decreased. Next to that we also looked if rapid changes in the heart rate were related to speed or not. The routes ran by runner 1 and the short evaluations of these training runs can be found in Appendix A.

4.3.2 Visualization

To visualize the trainings of runner 1 we created an app, with different aspects interesting for the runners. The app can be used by runners to plan routes and make training schemes. Next to that the runner is also able to track their run, as well as sharing their run afterwards. In this way team members can follow the runners' progress in an easy way.

The FAIR principles [34] were taken into account, when creating an app. On the discover page (fig. 39) you can find and access the results of your team members' runs. It shows what kind of training your team member went for, so if it was a short training or an interval training, for example. Next to that it also shows the distance and time ran by your team members, as well as their average speed and the increase of the run. The line shows the route run by your team member, without a map, to ensure the runners' privacy. Next to that the start and end point of the run are not shown, also to ensure the privacy of the runner. The color of the line is related to the pace of the runner. When the runner is running at a high pace the line is green. When the runner is slowing down the line turns from green to yellow, from yellow to orange and from orange to red. With red being the pace of the runner walking. The use of color is an effective way of making the speed changes of the runner visible. In this way team members can easily see if the runner is keeping a constant pace. It is also an easy way to compare runs, on pace, which makes it easy for the runner as well as the team members to see the progress. The names of the runners are not visible in the app to ensure the privacy of the runners. The team members can give direct feedback to the runner by commenting on the training. Lastly the weather conditions during the run are also included since this can have a substantial influence on the runner's results.

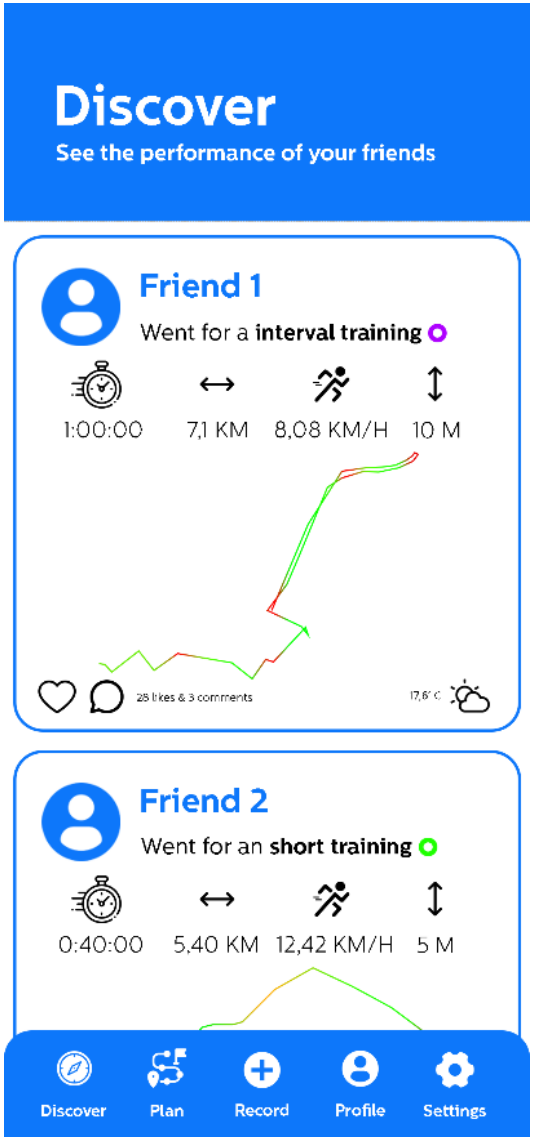


Figure 39: Discover page app

The plan page of the app (fig. 40) makes it easy to plan new routes you as a runner want to run. It shows the map, which makes it easy to create new routes. The app will also suggest routes to you as a runner, based on what kind of run you want to go for.

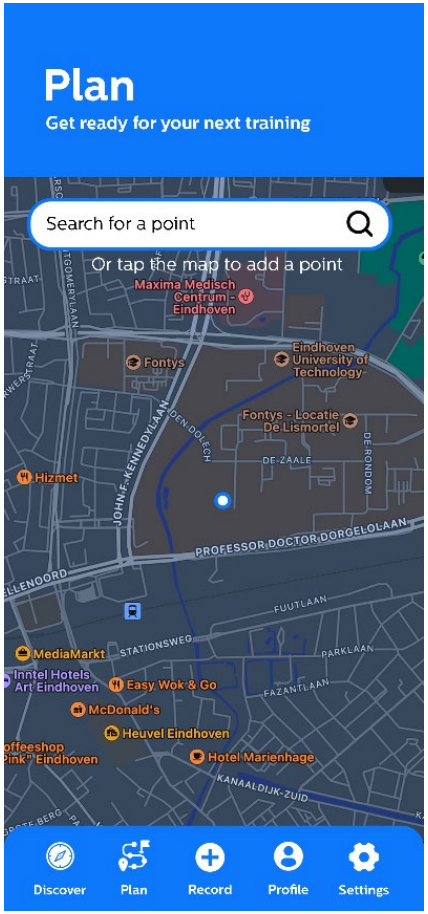


Figure 40: Plan page app

On the record page (fig. 41) you can start recording your run. When you want to start your training, you first select which kind of training you want to do. After that you are ready to start running. The app records the time and distance ran by the runner, as well as the speed of the runner. Next to that the increase of the run is also measured by the app. When the runner is done with its training, the recording can be stopped and posted by the runner. The training results will be posted on the discover page, as shown in figure 39. Next to that the training will also be added to the agenda of the runner (fig. 42). The runner does not necessarily have to use the recording possibility of the app, in order to post its progress. The app can also be connected to the smartwatch of the runner, which will synchronize the results of the run with the app. The data collected from the smartwatch will then be put into the same format as seen in figure 39.

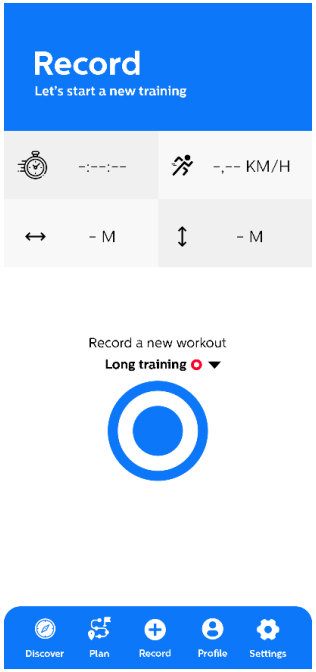


Figure 41: Record page app

The profile page of the app shows an overview of the runner's profile (fig. 42). On this page others can check your agenda, showing what runs you did. The agenda gives an overview of when you have trained. The circles show that you have trained on that day. The color of the circles are related to the different categories. So, a green circle shows that the runner has done a short training and a purple circle shows that the runner has done an interval training, for example. When you want more insights on a training, you can click on the circle, which leads you to the post of the training (fig 39). The agenda is an easy manner to give a quick overview of the days the runner has trained and what kind of trainings the runner did. This helps to decide strategies of the runner, which can help to form a tactic in preparation of a race. Next to the agenda, the profile page also gives insights on the runner's goals, as well as an overview of the growth of the runner. The profile page also gives the possibility of creating a training schedule, which can help the runner in its preparation for a race.

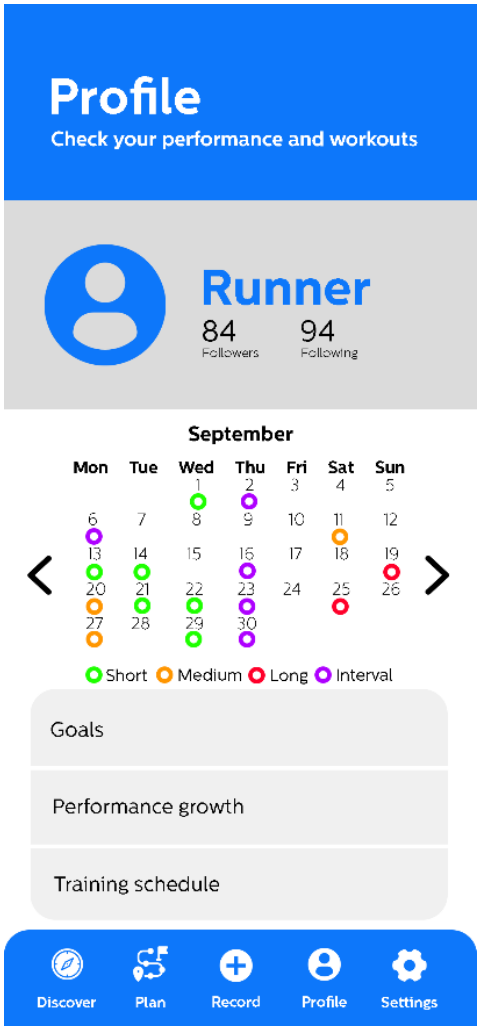


Figure 42: Profile page app

The app is a great way of visualizing the progress of runners for themselves, as well as for team members. While making the visualizations of the app, ensuring the privacy of the runners was the main focus of us.

4.4 Conclusion

In these two assignments we analyzed real-time data sets. From the datasets we learned that it is important to first clean the data, by removing outliers, to be able to analyses the data. Visualizations helped us to get a clear idea of what the information in the dataset means. It allowed us to identify outliers and gain insights into the performances of the runners. During the assignments, the FAIR principles were considered as well as the privacy of the runners.

In the first part of the assignment, we first analyzed all the participants to find their individual runner profiles. In order to do so, we looked at various things such as the changes in their pace and heart rate over time. This gave good insights into how well the runners arranged their race, if they started too fast or if they were able to keep the same pace during the race. By using the photos, qualitative data, we were able to make statements about, for example, the clothing and shoes they were wearing. We used all this information to determine their individual runner profiles. And after doing so, we were able to identify their runner profile as a team.

In the second part of the assignment, we analyzed and evaluated the training preparations of one of the participants. We looked at the length and duration of the trainings, as well as the speed and heart rate of the runner during each training. By looking at this we were able to quickly analyze and evaluate all the trainings, to find patterns and tactics. After the analyzation and evaluation, the trainings were visualized in an app, which shows the progress of the runner. The social aspect of the app allows the runner and his teammates to keep track of each other's progress and give feedback and share tactics, all in order to improve the performances.

CONCLUSION

At the start of this course, we were given qualitative and quantitative data. We used this data to analyze several runners and eventually were able to conclude the performance of these runners. Although not all runners performed equally well in terms of qualitative data, we were able to conclude from their quantitative data that most runners achieved their personal goals.

By analyzing the real-time datasets, we learned how important it is to first clean the data (remove outliers) in order to be able to analyze the data in a correct way. Visualizations helped to gain a better understanding of the information. This allowed us to identify outliers and to get a better image of the performance of the runner.

At the end of the course, we combined the real- time data sets with the data found on the internet to analyze the participants individually in order to find determine the individual and team runner profiles. Using a combination of datatypes allowed us to get a better image of the performances, which was then helpful when creating the app. By analyzing and evaluating the preparations we were able to find patterns and tactics. These insights are visualized in an app. In this way, the team members of the runner can give feedback to the runner and keep track of the runner's progress. During the assignments, the FAIR principles were considered as well as the privacy of the runners.

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APPENDIX

Appendix A – Training routes of runner 1

Date: 30 August 2021

- Category: Interval training
- Distance: 7.1 km
- Increase: 10 m
- Time: 1 hour
- Speed:
    - Fluctuating, since interval
    - Slowing down at the end
    - Average speed: 8.08 km/h
- Heartbeat:
    - Fluctuating, since interval – following speed change
    - Max: 165 bpm
    - Min: 95 bpm

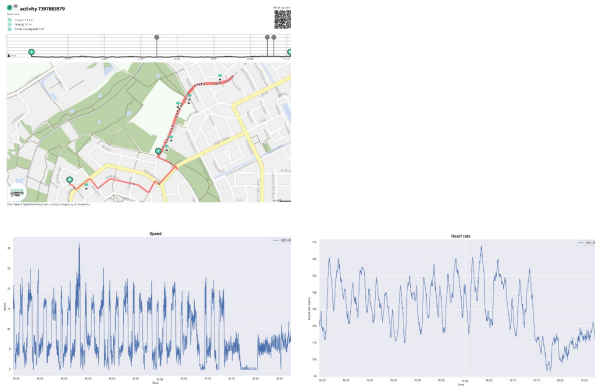

Figure 43: activity 7397883979

Date: 1 September 2021

- Category: Short training
- Distance: 5.4 km
- Increase: 5 m
- Time: 40 minutes
- Speed:
    - Constant
    - Average speed: 12.42 km/h
- Heartbeat:
    - Fluctuating
    - Max: 155 bpm
    - Min: 120 bpm

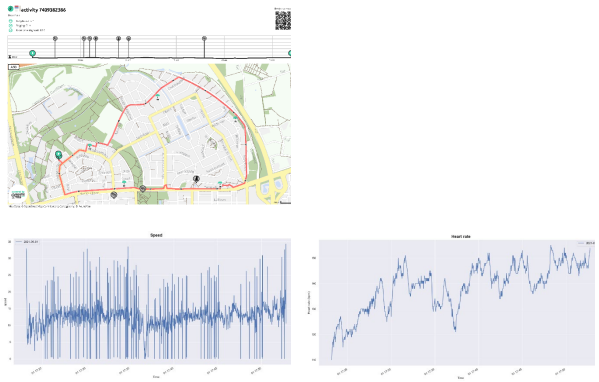

Figure 44: activity 7409382386

Date: 2 September 2021

- Category: Interval training
- Distance: 10.1 km
- Increase: 9 m
- Time: 1 hour 5 minutes
- Speed:
    - Fluctuating, since interval
    - Slowing down at the end
    - Average speed: 9.88 km/h
- Heartbeat:
    - Fluctuating, related to the speed change
    - Max: 160 bpm
    - Min: 100 bpm

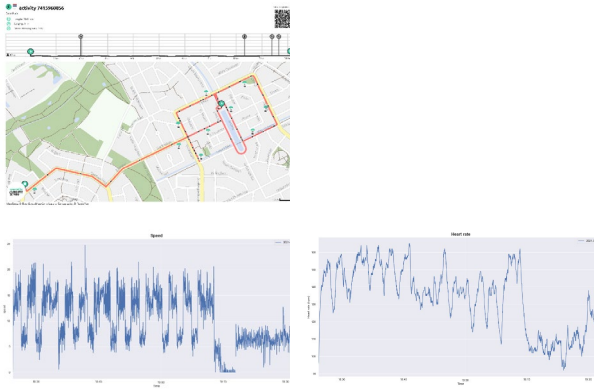

Figure 45: activity 7415960856

Date: 3 September 2021

- Category: Short training
- Distance: 4.5 km
- Increase: 5 m
- Time: 25 minutes
- Speed:
    - Constant
    - Average speed: 12.40 km/h
- Heartbeat:
    - Increasing
    - Max: 180 bpm
    - Min: 120 bpm

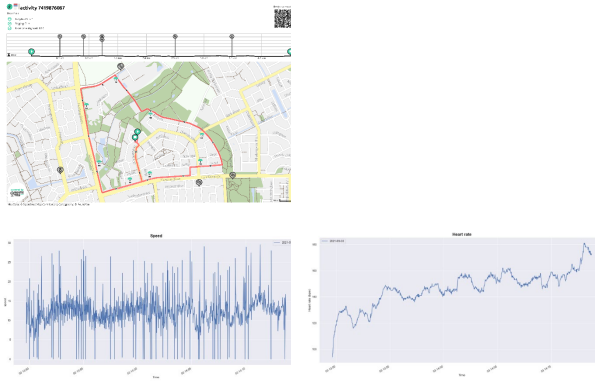

Figure 46: activity 7419876087

Date: 4 September 2021

- Category: Longer training
- Distance: 12 km
- Increase: 26 m
- Time: 1 hour 15 minutes
- Speed:
    - Constant
    - Slowing down at the end
    - Average speed: 12.08 km/h
- Heartbeat:
    - Increasing and in the end decreasing
    - Max: 185 bpm
    - Min: 120 bpm

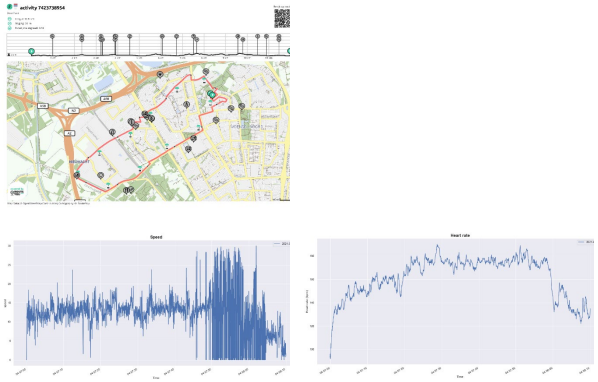

Figure 47: activity 7423738954

Date: 5 September 2021

- Category: Short training
- Distance: 4.5 km
- Increase: 5 m
- Time: 27 minutes
- Speed:
    - Constant
    - Average speed: 11.72 km/h
- Heartbeat:
    - Increasing
    - Max: 165 bpm
    - Min: 120 bpm

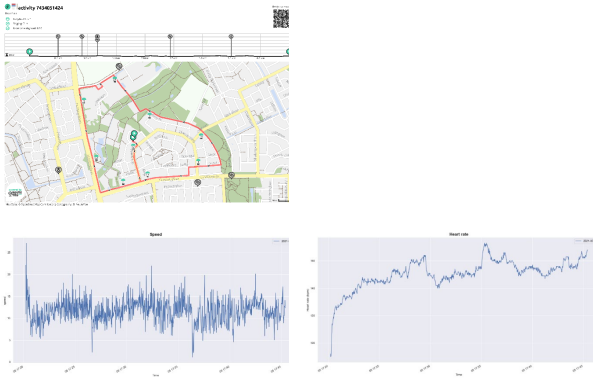

Figure 48: activity 7434051424

Date: 6 September 2021

- Category: Interval training
- Distance: 7.7 km
- Increase: 7 m
- Time: 1 hour 15 minutes
- Speed:
    - Slow at the beginning
    - Fluctuating, since interval
    - Slowing down at the end
    - Average speed: 6.94 km/h
- Heartbeat:
    - Fluctuating, related to the speed change
    - Max: 150 bpm
    - Min: 80 bpm

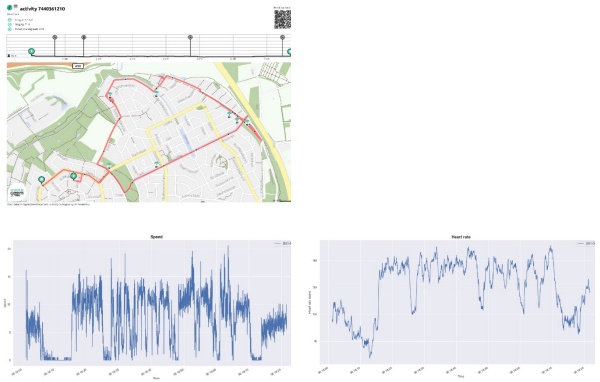

Figure 49: activity 7440361210

Date: 11 September 2021

- Category: Longer training
- Distance: 12.2 km
- Increase: 14 m
- Time: 1 hour 15 minutes
- Speed:
    - Constant
    - Slowing down at the end
    - Average speed: 11.33 km/h
- Heartbeat:
    - Slowly increasing and then decreasing
    - Max: 180 bpm
    - Min: 100 bpm

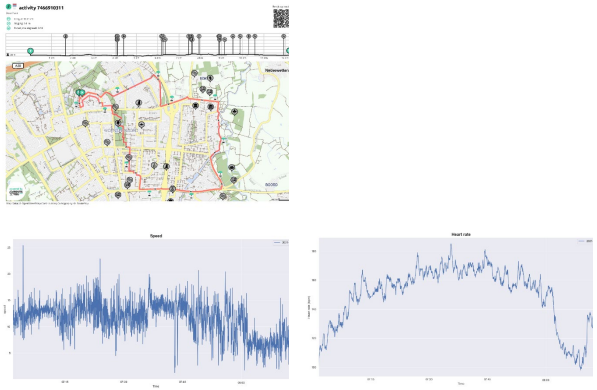

Figure 50: activity 7466910311

Date: 13 September 2021

- Category: Short interval training
- Distance: 5.2 km
- Increase: 4 m
- Time: 12 minutes
- Speed:
    - Fluctuating
    - Slowing down at the end
    - Average speed: 8.15 km/h
- Heartbeat:
    - Fluctuating, related to the speed changes
    - Max: 160 bpm
    - Min: 90 bpm

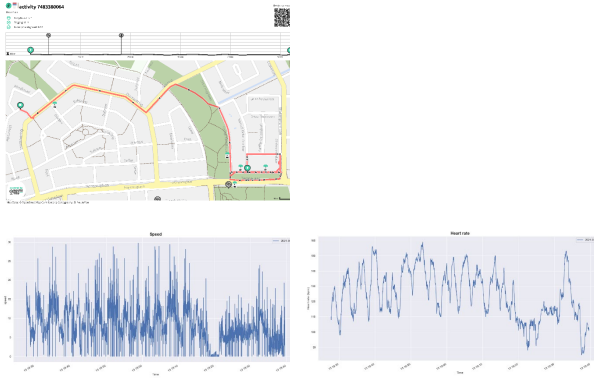

Figure 51: activity 7483380064

Date: 14 September 2021

- Category: Short training
- Distance: 4.3 km
- Increase: 10 m
- Time: 25 minutes
- Speed:
    - Constant
    - Average speed: 10.72 km/h
- Heartbeat:
    - Increasing
    - Max: 160 bpm
    - Min: 120 bpm

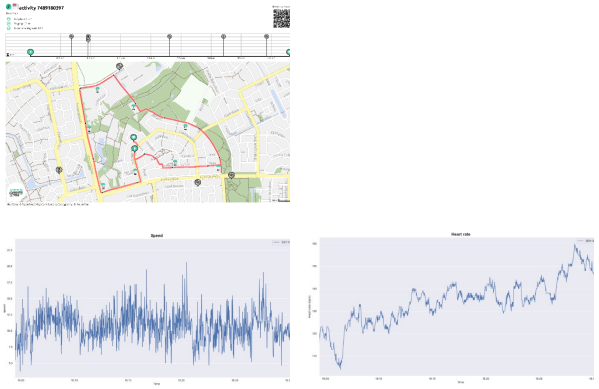

Figure 52: activity 7489180397

Date: 16 September 2021

- Category: Interval training
- Distance: 10.1 km
- Increase: 7 m
- Time: 1 hour 25 minutes
- Speed:
    - Fluctuating, since interval
    - Average speed: 8.27 km/h
- Heartbeat:
    - Fluctuating, related to the speed change
    - Max: 165 bpm
    - Min: 90 bpm

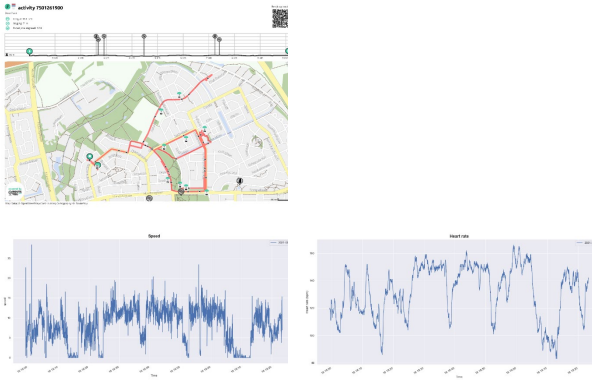

Figure 53: activity 7501261900

Date: 19 September 2021

- Category: Long training
- Distance: 16.2 km
- Increase: 51 m
- Time: 1 hour 30 minutes
- Speed:
    - Constant
    - Speed is higher than normal
    - Average speed: 13.02 km/h
- Heartbeat:
    - Constant – increasing – constant
    - Max: 180 bpm
    - Min: 120 bpm

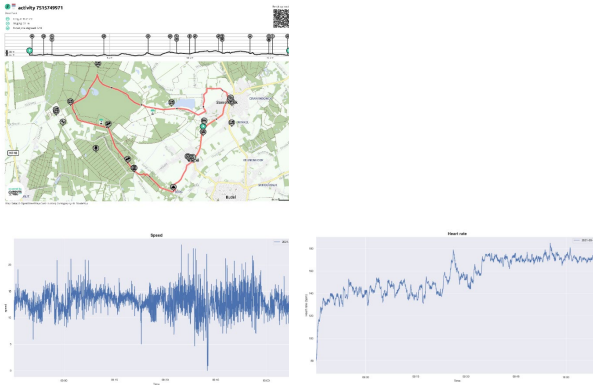

Figure 54: activity 7515749971

Date: 20 September 2021

- Category: Longer training
- Distance: 9.2 km
- Increase: 14 m
- Time: 1 hour 10 minutes
- Speed:
    - Fluctuating:
        - Slow at the beginning
        - Constant middle
        - Slowing down at the end
    - Average speed: 8.87 km/h
- Heartbeat:
    - Fluctuating, related to the speed change
    - Max: 165 bpm
    - Min: 95 bpm

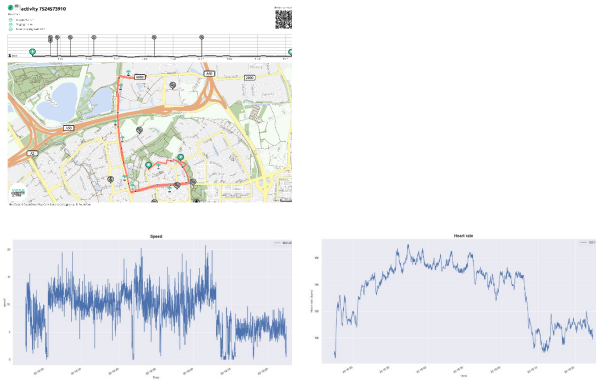

Figure 55: activity 7524573910

Date: 21 September 2021

- Category: Short training
- Distance: 3.5 km
- Increase: 3 m
- Time: 20 minutes
- Speed:
    - Constant
    - Average speed: 11.36 km/h
- Heartbeat:
    - Increasing
    - Max: 150 bpm
    - Min: 110 bpm

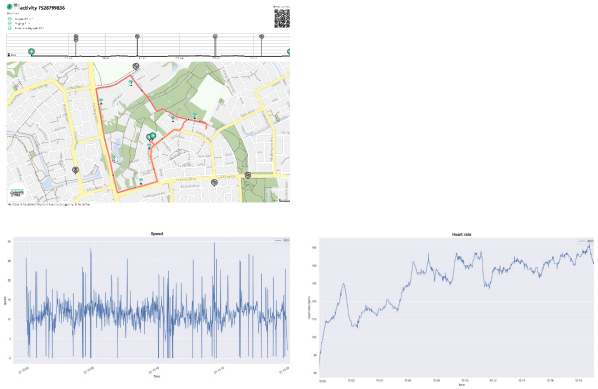

Figure 56: activity 7528799836

Date: 22 September 2021

- Category: Short training
- Distance: 5.4 km
- Increase: 5 m
- Time: 1 hour 15 minutes
- Speed:
    - Constant
    - Average speed: 11.86 km/h
- Heartbeat:
    - Increasing
    - Max: 175 bpm
    - Min: 130 bpm

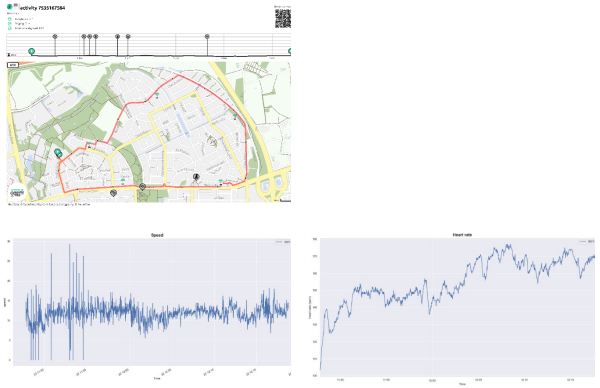

Figure 57: activity 7535167584

Date: 23 September 2021

- Category: Short interval training
- Distance: 4.5 km
- Increase: 12 m
- Time: 1 hour 7 minutes
- Speed:
    - Fluctuating, since interval
    - Slowing down at the end → constant slow speed
    - Average speed: 9.52 km/h
- Heartbeat:
    - Fluctuating and in the end decreasing, related to the speed changes
    - Max: 160 bpm
    - Min: 80 bpm

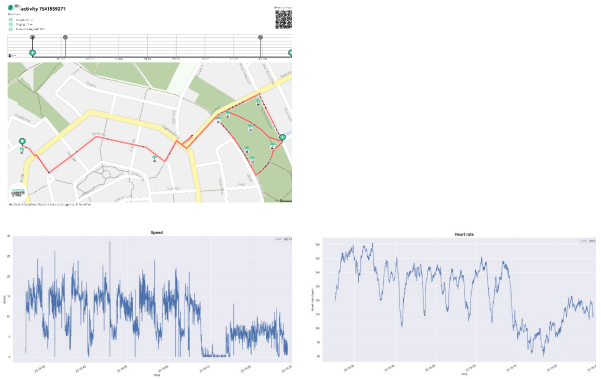

Figure 58: activity 7541959271

Date: 25 September 2021

- Category: Long training
- Distance: 17.9 km
- Increase: 32 m
- Time: 2 hours
- Speed:
    - Beginning constant, halfway starts fluctuating
    - Average speed: 10.29 km/h
- Heartbeat:
    - Fluctuating, related to the speed changes
    - Max: 175 bpm
    - Min: 115 bpm

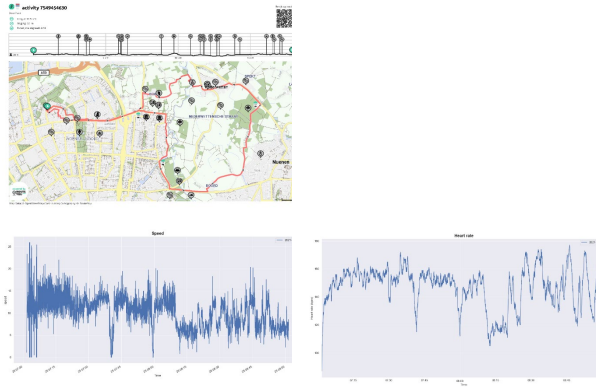

Figure 59: activity 7549454530

Date: 27 September 2021

- Category: Longer training
- Distance: 14 km
- Increase: 17 m
- Time: 2 hours 15 minutes
- Speed:
    - Fluctuating
    - Speed is slower than normal
    - Average speed: 7.51 km/h
- Heartbeat:
    - Fluctuating, related to the speed changes
    - Max: 155 bpm
    - Min: 90 bpm

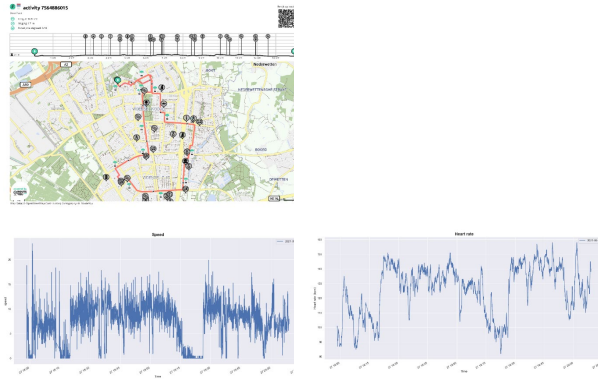

Figure 60: activity 7564886015

Date: 29 September 2021

- Category: Short training
- Distance: 4.3 km
- Increase: 9 m
- Time: 23 minutes
- Speed:
    - Constant
    - Average speed: 12.28 km/h
- Heartbeat:
    - Constant, but fluctuating
    - Max: 165 bpm
    - Min: 140 bpm

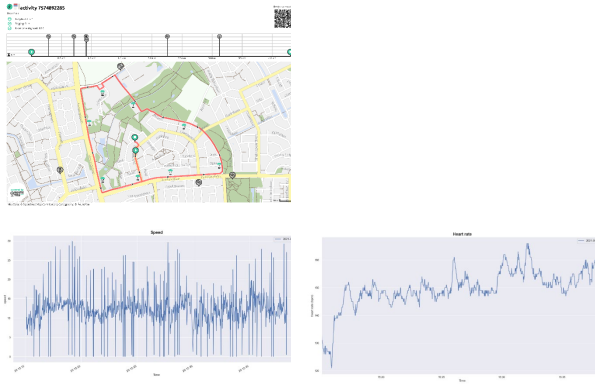

Figure 61: activity 7574892285

Date: 30 September 2021

- Category: Interval
- Distance: 10.3 km
- Increase: 16 m
- Time: 1 hour 15 minutes
- Speed:
    - Fluctuating, since interval
    - Slowing down at the end
    - Average speed: 9.20 km/h
- Heartbeat:
    - Fluctuating - in the end decreasing
    - Max: 160 bpm
    - Min: 85 bpm

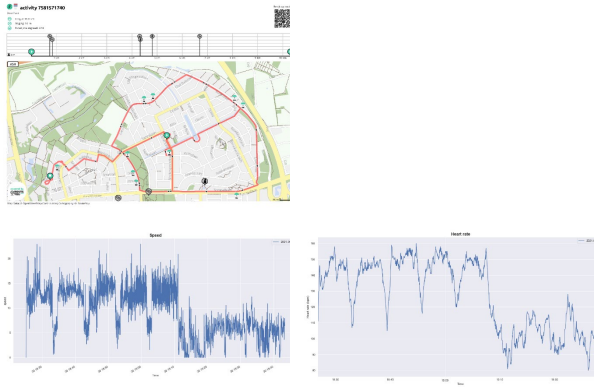

Figure 62: activity 758157140

Date: 2 October 2021

- Category: Longer training
- Distance: 10.4 km
- Increase: 21 m
- Time: 1 hour
- Speed:
    - Constant
    - Slowing down at the end
    - Average speed: 11.84 km/h
- Heartbeat:
    - Increasing – constant – decreasing
    - Max: 185 bpm
    - Min: 120 bpm

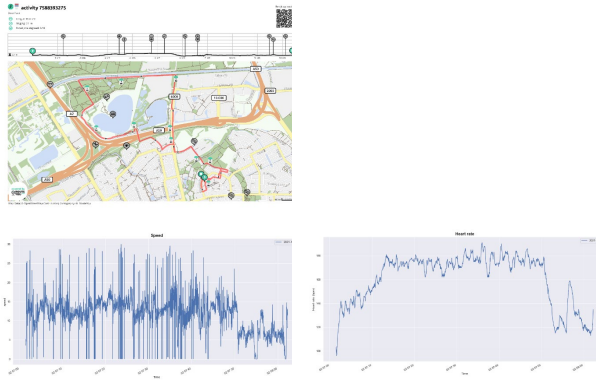

Figure 63: activity 7588393275

Date: 3 October 2021

- Category: Short training
- Distance: 3.2 km
- Increase: 6 m
- Time: 17 minutes
- Speed:
    - Constant but fluctuating
    - Average speed: 12.17 km/h
- Heartbeat:
    - Increasing
    - Max: 170 bpm
    - Min: 120 bpm

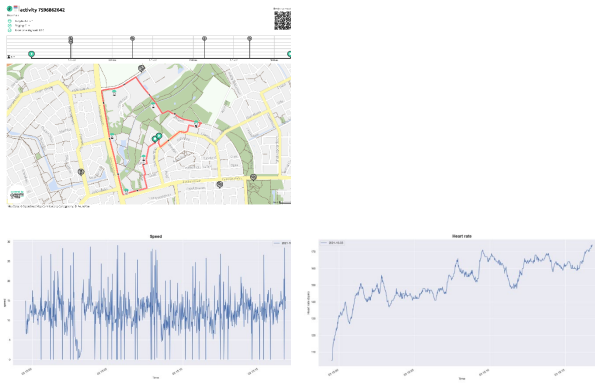

Figure 64: activity 7596862642

Date: 4 October 2021

- Category: Longer training
- Distance: 10.0 km
- Increase: 12 m
- Time: 1 hour 30 minutes
- Speed:
    - Fluctuating
    - Average speed: 8.34 km/h
- Heartbeat:
    - Fluctuating, related to speed change
    - Max: 165 bpm
    - Min: 80 bpm

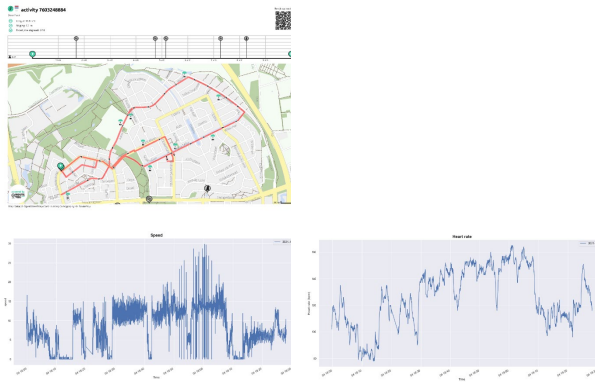

Figure 65: activity 7603248884

Date: 7 October 2021

- Category: Longer training
- Distance: 9.3 km
- Increase: 22 m
- Time: 60 minutes
- Speed:
    - Constant
    - Average speed: 12.33 km/h
- Heartbeat:
    - Increasing
    - Max: 185 bpm
    - Min: 135 bpm

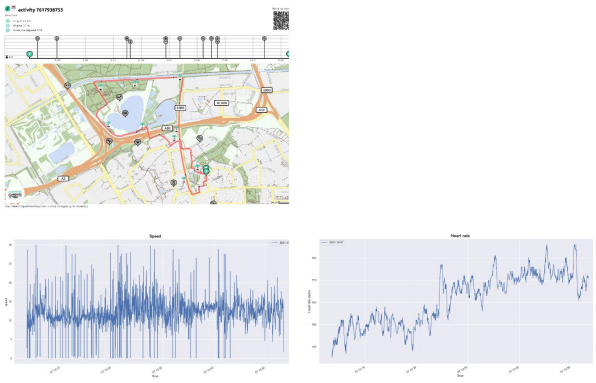

Figure 66: activity 7617938753

Date: 9 October 2021

- Category: Short training
- Distance: 3.3 km
- Increase: 7 m
- Time: 16 min
- Speed:
    - Constant
    - Average speed: 11.91 km/h
- Heartbeat:
    - Fluctuating, not related to speed change
    - Max: 150 bpm
    - Min: 125 bpm

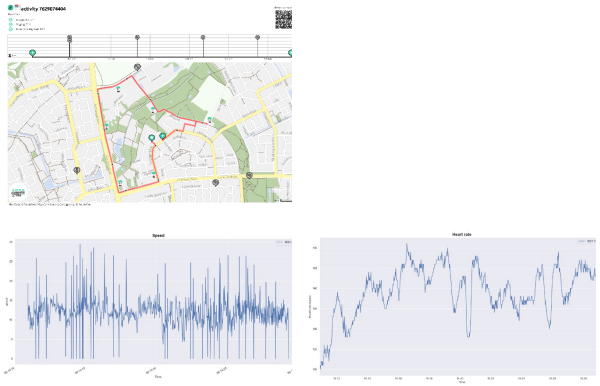

Figure 67: activity 762907440