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Conference abstract

Real-time energy monitoring of track cyclists

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Abstract: In order to support track cyclist coaches in the monitoring of their riders and the analysis of their data, the Wireless Cycling Network project of Ghent University and Cycling Vlaanderen focuses on developing a central sensor dashboard on which the sensor data (such as power and heart rate) of all riders will be visualized in real-time and events/outliers can be thrown. Changes in energy level is one of the events the demonstrator currently supports and this paper mainly explains how this is done. Other events follow a similar workflow.

Keywords: ANT+, wireless, monitoring, sensors, energy, track cycling.

1. Introduction

In cycling disciplines such as track cycling and time trialing pacing is an integral part of a good performance [1,2]. Good fitness is essential but it is also critical that a rider uses its available power in the right moment in a race or an effort. A Madison rider will use its energy in a different way than a rider who is a empting to break the world hour record. Coaches cannot directly look in the head of the rider or "feel their legs". Sensor data can provide them the required insights in a rider's performance, however, it is usually only analyzed after a workout or race. The only clue they usually have are the lap times. This study tries to investigate the possibility to fill this void by trying to provide coaches with real time insights in a rider's energy levels by the capturing and processing of the sensors worn by athletes and/or installed on their bicycles and link them to a location on the track.

Fig. 1: Hardware setup of WASP (NPE) (top left corner) sensor capture devices.

2. Materials and Methods

As mentioned in the introduction the main goal of this research project is the provision of a real time and extensible sensor data platform for coaches supervising the training session / race.

ANT+ has been the industry standard for communication between sensors (e.g., heart rate monitors, power meters and speed/cadence sensors) and head units (e.g., Garmin, Wahoo or Polar). Most modern sensors also support Bluetooth Low Energy but ANT+ is still widely used as it is low power and tailor made for this type of sensor to master unit communication.

The WASP device (North Pole Engineering [3], see Figure 1) is a device that is capable of capturing ANT+ data of multiple devices in its vicinity. For every captured ANT+ datagram it is also broadcasting the Received Signal Strength Indicator (RSSI) from every WASP receiver that was able to capture data from a specific sensor. Furthermore, it also has WiFi functionality and is able to capture the ANT+ datagrams and multicast them on a wireless network.

Fig. 2: *Schematic overview of sensor data capturing within the WCN project.*

Figure 2 shows a schematic overview of how these separate building blocks are brought together to capture and centralize the athletes' data. Multiple WASP receptors are positioned along the cycling track and multicast the received ANT+ packages in a wireless network that is managed from a central router / access point. The multicast packets are received and processed on a central computer connected to the same network using the Application Programming Interface (API) provided by the WASP manufacturers.

With these three essential building blocks (i.e., the WASP array, network infrastructure and computer processing application) a number of interesting insights can be derived and/or calculated from the captured data on the central computer. In the remainder of this paper we will mainly focus on this part of the study. In the results section we will concisely discuss the software architecture and present some results of field tests using this architecture (hardware and software). In the discussion section we will briefly discuss the key findings we had during our project and finally in the practical applications section we will discuss current and future use of our methodology.

3. Results

The first part of our practical implementation consisted of determining how many WASP capturing devices we needed and where to position them. Ideally, we want to install the least amount of devices but still want to provide reasonable data granularity. As mentioned, a rough estimation of where the rider and its emitting sensors are on the track could give coaches and athletes even more chances to fully exploit the generated data.

For testing the "Eddy Merckx" cycling track in Ghent was used. It is a 250 meter long indoor track that is used by both recreational and professional riders. After extensive testing the WASP receivers were positioned as follows: at the finish line, in the first corner, on the second straight and the second corner.

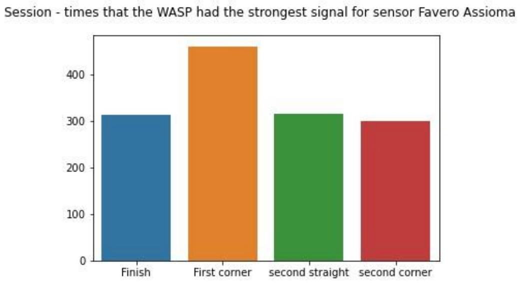

Fig. 3: *Bar plot of how many times a WASP capturing device had the strongest signal for a Favero Assioma power meter during a recorded session.*

As illustrated in Figure 3 this setup yields a homogenous distribution of when a certain WASP was the device with the strongest connection (i.e., highest RSSI) to the sensor (i.e., the Favero Assioma power meter). The value of the first corner is slightly higher as riders enter and exit the track in this zone.

The distribution of all RSSI values of the WASP setup is shown in Figure 4. Similar to the results in Figure 3 the reported RSSIs are very homogenous, which further fortify the decision of the WASP array placement. Furthermore, for a certain moment in time, different WASP devices can receive the same sensor value, but each with different RSSI values. This information can ultimately provide us with a zone estimation of the sensor (and thus athlete).

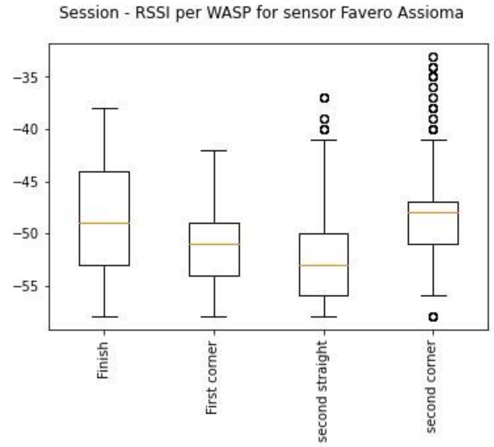

Figure 4: Distribution of RSSI values recorded by all the different WASPs (even if they didn't have the strongest RSSI).

This principle is illustrated in Figure 5 where an athlete did four laps of the track. The blue lines are the prediction of the location prediction algorithm and the dots are the actual ground truth when the athlete passed by the WASP. The algorithm used for this *zone prediction* is a voting based algorithm that smoothens and finds peaks in the RSSI signals for different sensors on different WASP receiving devices.
Furthermore, Figure 5 also illustrates that a voting approach with multiple sensors of an athlete (bottom graph) works better.

The final step is to store the produced sensor data and link them to athletes. This is achieved with a .NET backend that handles database connection with a Mongo database, reads data on the WASP WiFi network and advertises this information through an API (data stored in the Mongo database) and a WebSocket (to broadcast live sensor data to the front-end. The front-end is written with the React JavaScript framework and uses the .NET API and sockets to retrieve and/or store data.

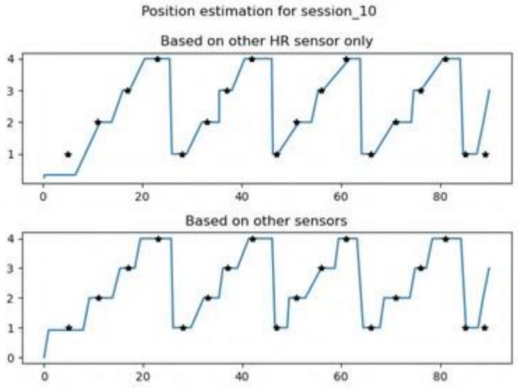

Figure 5: Location algorithm based on a single sensor (top) and multiple sensors (bottom) worn by the athlete who performed 4 laps of the track.

4. Discussion

In conclusion, the combination of the sensor data capturing and logging and the location estimation based on sensors attached to a rider are the building blocks to build an usable application for coaches to monitor the athletes out on the track.
Furthermore, a user-friendly application was built to present the insights in real-time to the coaches. With the supplied tools, coaches can make instant modification to a pacing plan and/or to the race tactics.

5. Practical Applications.

In previous sections the hardware and software building blocks of our realtime track monitoring platform were discussed. The proposed solution puts all elements in place to produce insightful analytics during training sessions. As an example and based on the recorded power values for an athlete a plugin in the front-end was implemented to provide coaches a direct insight in the energy reserves (e.g., W' balance) of an athlete [3]. This is especially helpful to monitor if the requested training load is too high/low/ideal.

The application also has a secondary benefit, as a session viewer was implemented as well. This allows coaches and athletes to retrospectively analyze the training session and export it to a Flexible be directly uploaded into popular analysis software such as Strava [5], TrainingPeaks [6] or TodaysPlan [7]. The centralization of the data gathering alleviates the responsibility of the athletes to bring GPS units for data recording. Furthermore, these devices cannot be mounted in direct sight of the athlete on the bicycle so athletes often forget to start or stop their data recordings.

Fig 6.: *Realtime central display of sensor data while track training is performed.*

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Conflicts of Interest: The authors declare no conflict of interest.

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