Cyclo – A Personal Bike Coach Through the Glass

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Figure 1: *User interface mockups. Left: The biker records an interesting section of the ride; Middle: Track overview while the biker is behind the time plan; Right: Location-triggered notification (please zoom in for viewing)*

Abstract

We present Cyclo, our prototype of a personal assistant for bike training using Google Glass. We describe our requirement study with 35 users and our design process for developing a novel application for Glass. Our hands-free user interface is potentially more convenient to use than traditional speedometers, and it provides instant performance feedback and context-aware notifications overlaid on the biker's view.

CR Categories: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems – Artificial, augmented, and virtual realities

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1 Introduction

Consider the following imaginary scenario: Michael, a semi-professional biker is preparing for the annual bike race around the lake in his neighborhood. Just like every day after school he rides three rounds around the lake and records his timings. He also shares his current status with his friends online. On the display in his sunglasses he can see his current progress compared to his all-time best round and also compared to his brother who won the race last year. After the second round his wearable bike computer alarms that a thunderstorm is approaching and he should return home soon. He decides to do so because he has also received a text message from his mother that the dinner is ready. On the way uphill he takes a nice shot of the village by a simple speech command. Michael meets his brother at the town hall where he was waiting for him based on his live position updates. Michael then calls their mother that they will arrive home soon.

Certainly, we are not far from the described story to turn into reality. Latest generation smart gadgets have recently opened the way for computer support in everyday sports training. For instance runners and skiers track their trips with GPS-enabled watches, golfers and hunters benefit from special navigation devices, fitness trainers check on their exercises with wearable sensors, and bikers ride with sophisticated cycling computers. There is a clear trend, however, that the features of these custom devices merge in our smartphones we carry in our pockets around the clock. But while the smartphones have excellent sensing and processing capabilities, they may be cumbersome to interact with if our hands are occupied during sports.

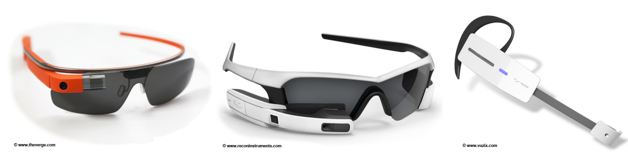

Figure 2: *Newest generation wearable computers. From left to right: Google Glass, Recon Instuments JET, Vuzix M100.*

The upcoming release of commercial head-mounted computers (examples are shown in Figure 2) such as the Google Glass[1], the Recon Instuments JET[2], and the Vuzix M100[3] can be expected to boost the adoption of smartphone-based sports equipment by extending the smartphones with new interaction paradigms. Their see-through display, built-in sensors, and most importantly their hands-free user interface bear the potential to turn them into great sports accessories. Compared to a traditional cycling computer, the Glass for example has built-in GPS, compass, inertial sensors, camera, a colorful display of size 640x360 pixels, a smartphone-equivalent CPU, a touchpad, and speech recognition. By combining a head-mounted computer with a smartphone that provides permanent Internet connectivity a rich variety of real-time services for sportsman can be realized.

In this paper we present Cyclo, our prototype of a bike assistant application on a Glass device for personal and collaborative training.

[1] http://www.google.com/glass
[2] http://jet.reconinstruments.com
[3] http://www.vuzix.com

We describe our interface design process based on a requirement study with 35 participants, and our first impressions about developing for the Glass platform.

2 Related Work

The use of technology in sports training is nowadays a general practice to measure, analyze and document performance and progress especially in professional environments. Computers have a long tradition in sports for numerical modeling, statistical analysis and simulation, measurement of biomeachnical data and documentation [Baca 2006].

Computer-supported training [Wiemeyer 2006] is a research field that aims to integrate information technologies into sports training. Early research and application in this direction has shown the potential for bicycle training (e.g. [Fliege et al. 2006]) and introduced the vision of ubiquitous computing [Weiser 1995] in sports technology. Computer supported collaborative sports [Wulf 2009] represents a research direction in ubiquitous games and computer augmented sports that is mainly driven by computer gaming research. From that perspective Reilly proposed a taxonomy for computer-augmented sports systems [Reilly 2009].

To our knowledge only few work on wearable computing and see-though displays has been done so far in sports technologies. Most sports-related research focuses on the use of wearable sensors to track the training progress [Asselin et al. 2005], [Kiryu and Yamashita 2007], [Kranz et al. 2013]. Open heart cycling[4] is another promising approach that aims to improve social interaction of team members by displaying the heart rate on the back of the helmet, but the work is in an very early stage.

In summary, there exist numerous research prototypes and models for cycle training in the literature. But with the upcoming heads-up technology much more will be possible not only for professional athletes but even for non- and semi-professional trainees. In contrast to related work we investigate how cycle training can be supported by providing context-aware information to the user.

3 Requirement Survey

We have conducted a short survey with 35 persons (15 semi-professional and 20 hobby bikers) what kind of features they would favor in a biking assistant that can be possibly built into glasses. The answers can be summarized in the following categories.

Performance Measurements
: Every participant listed performance measurements (current speed, average speed, distance, stopwatch, burnt calories) to be important. Eight participants also mentioned the importance of on-body sensors such as a heart rate monitor with wireless communication.

Performance Comparison
: According to our survey the users also want to see their performance compared to other users. One possibility could be to race against own measurements recorded in the past and played back as a virtual partner. Second, sharing recorded training data in social networks allows for persuasion by friends. Furthermore, live sharing of the current position can assure family members about being safe and can inform fans who want to follow a specific biker.

Navigation
: Further important requirements are navigation and various maps. Elevation profiles and other track information are especially useful for mountain bikers.

Assistance Notifications
: An ideal biking assistant should provide real-time traffic and weather information which is nowadays available at free online services. Two participants came up with the idea of bike-mounted wireless sensors that report road quality and weather conditions to others in a vehicle area network (VANET).

Video Recording
: Six participants imagined some kind of live object/scene recognition using a bike-mounted camera. Three of them would also find infra-red cameras useful in dark forest trails. Nevertheless, live video recording is useful for post-ride performance analysis and accident investigation. The camera combined with high-speed wireless communication would allow for eye swapping with the coach.

Virtual Trainer
: Six participants (all BMX riders) would find a virtual video trainer helpful for learning tricks. A display is also useful for indoor gym training to show entertaining content during cycling.

Communication
: The professional bikers in our survey declared communication with their teammates and their coach a key feature of a biking assistant.

Interaction
: Most users mentioned in our survey that the interaction with a biking assistant must be limited to a few big buttons or a touch screen and the user interface must be very clear and well readable. The reason is that the biker's attention has to be split between the device and the road during interaction.

Form Factor
: A biking assistant must be weather-proof and dust-tight while it also has to be light and easy to mount on the bike/on the body. It has to be powered either directly from the bike or its battery should last at least a day in operation.

The above answers show that most feature requirements for a biking assistant are actually also available in today's wearable glass computers provided that they are connected to the Internet. We can conclude that a wearable computer like Google Glass combined with a smartphone has the potential to replace traditional cycling computers and GPS devices. Furthermore, a head-mounted computer can provide even hands-free interaction that might be more convenient and safer to use than bike-mounted devices.

4 User Interface Design

Based on our requirement study described in section 3 we identified four main design goals: (1) continuous status display, (2) ambient notification of context, (3) hands-free interaction and (4) communication between teammates. In the following subsections we discuss the identified goals separately.

4.1 Status Display

With Glass, the visual feedback is always available and there is no need to look down on the speedometer. The display is situated upright and overlays only a limited field of view. It is not intended for immersive augmentation but only for extending a small part of

[4] `http://exertiongameslab.org/projects/open-heart-cycling`

the view with additional information. Its small size requires careful content design for which guidelines[5] and tools[6] already exist.

During biking, Cyclo enhances the biker's view with information depending on the actual context. Status such as actual speed, distance and time is continuously presented as well as an overview elevation map. The biker's progress compared to the plan is indicated with different colors (see Figure 3). We encourage bikers to push their performance boundaries by racing against themselves, i.e., their previous timings on the same track. We also touch the concept of computer supported collaborative sports [Wulf 2009] by allowing bikers to race against the recordings of their friends. We chose to show only the minimum necessary information on the main display and other features can be activated by explicit user request (via speech, head gestures or swiping on the touchpad).

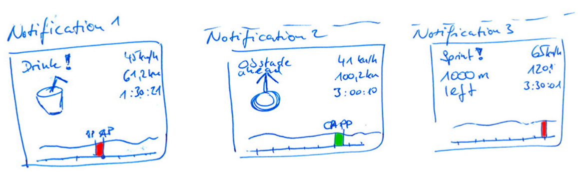

Figure 3: *User interface sketches with status and notifications*

4.2 Notifications

Cyclo allows the user to prepare the track in advance by defining the route and points of interests (POIs) on the map. Such POIs include checkpoints, dangerous sections, etc. Timing goals and nutrition plan associated with locations are also defined in this offline phase. During biking the notifications appear depending on the context. The notifications include the points of interest but also warnings about changing weather conditions or other notifications from the smartphone.

4.3 Interaction

The Glass user interface is focused on micro interactions that do not distract the user from what he/she is actually doing. On bike computers, for example, notifications are shown on the whole screen and the biker has to physically touch the unit to dismiss it. With Glass, the built-in gaze detector and inertial sensors allow for acknowledgement by simply looking up and nodding with the head. Switching between different contents (e.g., status display, navigation, etc.) can be realized for example with Google's speech recognition engine (requires network connectivity) without releasing the steering wheel.

4.4 Communication

The Glass has no cellular radio unit but it can be tethered to a smartphone via Bluetooth and can be used for team communication.

We have created paper mockups of our interface concept that have been revised by six bikers. The final user interface has been implemented on a Glass device.

[5] http://developers.google.com/glass/ui-guidelines

[6] http://www.glasssim.com

5 Implementation

In this section we describe our implementation questions and our first impressions about development for the Glass platform. Glass applications can be built in two fundamentally different ways, either with the official Mirror API or like conventional Android applications.

5.1 Glass Mirror API

The Glass Mirror API is the only officially supported method of implementing a Glass application. It is a cloud service that accepts RESTful messages from an application either directly or via a custom backend, and relays them to the user's Glass device. Contents appear to the user as so called cards on a timeline. The cards can use one of several predefined presentation layouts or a custom layout based on a limited subset of HTML.

The Mirror API provides several advantages but has some disadvantages as well. The predefined card layouts are targeted directly for the Glass resolution and unique display properties. A Glass user will already be familiar with those layouts. On the other hand, the RESTful service requires constant reliable Internet connection for real-time experience. Also, the official documentation is currently rather sparse. There is little community support since very few developers have been working on Glass applications so far. There is no option for creating a custom layout beyond a limited subset of HTML tags.

5.2 Stand-alone Android Application

Since the Glass device has a standard Android operating system, it can run practically any Android application that does not require keyboard or touch-screen input.

A stand-alone Android application has direct access to all the hardware sensors of the device and the rich Android graphical user interface library. Developers can make use of the extensive set of Android development tools, both official tools from Google such as the *Android Studio* and third-party frameworks such as *PhoneGap* or *Processing*. This way of development also offers real-time responsiveness, offline work, an extensive widget library for creating custom views, and perhaps the most important property of a modern programming framework - strong community support.

However, as this is currently an unofficial way for creating Glass applications, it has some drawbacks. While regular Android applications are started from a dedicated "launcher" app, the standard Glass launcher does not allow starting third-party applications. This means unofficial apps can only be started while connected to the developer's computer. Also, there is currently no commercial means of distributing apps created this way. Android applications are distributed through online app stores such as Google's Play store and Amazon's Appstore that currently do not support Glass apps.

5.3 Cyclo Prototype

Our two main requirements for the Cyclo prototype development were responsiveness even in the likely situation of offline access, and fast programming iterations using proven knowledge and community support, so we chose for the strategy of a stand-alone Android application.

The route and points of interests are preloaded to the app as GPX (GPS eXchange Format) files and are loaded to the memory on application start. The Android location manager service is used both for tracking current location and for creating proximity alerts for points of interest. The progress view (see Figure 1 in the middle) gets updated on each location update. The notification view (see Figure 1 on the right) is shown for a short time when a proximity alert about a point of interest is triggered.

To simulate a ride we have manually created another GPX file containing the simulated route. A simulator component would read the GPX file on application start and trigger a fake location update on each entry, according to its timestamp, using a mock location provider.

6 Discussion and Conclusion

We have conducted interviews with six bikers where they judged both our user interface mockups and our initial prototype on Glass. They found that Cyclo is very intuitive to use, it creates instant user engagement and there is little to no learning curve. Cyclo has clear advantages with the heads-up visual feedback and hands-free voice control compared to traditional speedometers. The subjects found the ambient notifications particularly helpful.

We have to note, however, that Cyclo requires constant network connectivity and GPS coverage that might not be available in rural areas. Traditional speedometers with wheel-mounted sensors can also provide precise speed measurement where GPS is not available. The retail price of Glass is not known yet but newspapers report it to be around 300 USD. A speedometer costs between 30 and 100 USD and a professional GPS costs between 300 and 900 USD.

As a smartphone is also part of Cyclo, the vast amount of existing sports gadgets and smartphone accessories can be easily integrated. The assistant could for instance warn the biker if the heart rate is too high or if he/she is likely dehydrated. While a pure smartphone-based assistant is difficult to mount on the handle bar and is subject to damage, Cyclo presents all information directly into the eye of the biker allowing the smartphone to be put away in a bike pack. The built-in microphone and bone conduction transducer allow for communication with teammates. Cyclo could also be extended to integrate tracks and training programs from crowdsourcing platforms such as *Bikemap*[7] or *Garmin Connect*[8].

During our experiments we found that the Glass device became hot after about five minutes image processing. The hardware is not designed for continuous recording but is reasonably good for single image capture. Because of the heat problem we find (the currently available developer version of) Glass not suitable for continuous image processing and scene analysis. The battery lasts for about 5 hours with intensive usage which we find acceptable. There is room for optimization here by splitting tasks between Glass and the connected smartphone. Future helmet designs may be combined with Glass and may even extend it with additional batteries.

At the time of preparing the camera ready version of this paper, Recon Instruments started an advertisement campaign about the JET wearable computer and the advertisements focus on a biking assistant usecase. JET seems to have a more suitable form factor than Glass because its battery is mounted on the opposite side than the display and not behind the ears. This form is better balanced and fits easier under the helmet. JET will be already shipped as sunglasses and its display is situated below the eye. It also runs Android OS and it can also be tethered to a smartphone for communication. Its hardware specifications are similar to that of Glass. Both Recon Instruments and Google announced the first commercial products to be available in 2014. Once both available, we plan to compare the two devices whether the above-eye or below-eye display is better suited for biking applications.

In conclusion, Glass and head-mounted computers in general represent a promising new technology for computer aided sports training. It is important to note that this work is based on an initial prototype which employs mock data and mock interfaces. A true usage study with a large number of subjects can only take place once the devices are commercially available. Our future research will focus on exploiting further capabilities of Glass. Our next step is to explore how to control the display content via head pose, followed by a thorough user study with professional bikers.

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[7] http://www.bikemap.net

[8] http://connect.garmin.com