LightWatch: A wearable light display for personal exertion

Jutta Fortmann[1], Janko Timmermann[2], Bengt Lüers[1], Marius Wybrands[1], Wilko Heuten[2], and Susanne Boll[1]

[1]University of Oldenburg, Germany
[2]OFFIS Institute for Information Technology, Oldenburg, Germany

Abstract. Wearable devices need to seamlessly integrate into everyday life and meet a user's aesthetic needs. In this paper, we present LightWatch, a wearable light display integrated into a common analogue wristwatch without interfering with the functionality of the watch itself. Input is enabled through a pressure-sensitive bezel mounted beneath the light display. LightWatch shall raise body awareness by enabling sensor-based measurement, adjustment and display of a user's personal exertion level. We see LightWatch as a promising approach for an unobtrusive everyday companion that can be used for various applications.

Keywords: wristwatch, digital jewellery, LED, pressure sensitive, heart rate

1 Introduction and Background

In the last years, wearable devices have been widely disseminated. A body-worn device needs to integrate seamlessly into everyday life and to meet a user's aesthetic needs. Thus, the latest trend on the wearable market is towards good-looking solutions, often referred to as digital jewellery.

In this work, we present a wearable light display for personal exertion. Our aim was to develop a wearable system that is integrated into a common wristwatch and seamlessly integrates into everyday life. We expanded an off-the-shelf analogue wristwatch by a pressure-sensitive light display and a heart rate sensor. LightWatch serves as a proof of concept that the integration of a pressure-sensitive light display into a common analogue watch is possible without interfering with the functionality of the watch itself. We see LightWatch as a promising approach for a useful everyday companion that meets a user's aesthetic needs and can be used for various use cases. One scenario is the raise of body awareness. We implemented this by enabling the user to measure her or his heart rate and to adjust a measured value whenever he or she thinks it does not match his or her perception. This way, a user is trained to assess his or her perceived exertion level.

Some research has investigated light displays that present information on wrist-worn digital jewellery, such as watches [1] or bracelets [2]. Besides, different input methods have been researched. These were e.g. mechanical pan, twist, tilt and click on the bezel [3], and touch gestures performed on the wristband [4]. In contrast to previous work, we integrate a point light display into a common analogue wristwatch without interfering with the functionality of the watch itself. Further, our light display can be intuitively operated via pressure that a user applies directly to the surface of the light display.

2 LightWatch

The idea of LightWatch is to present information about a user's exertion level on a common wristwatch. It was developed in an iterative design process. During the process, we repeatedly tested the hardware elements in our lab, both, separately, and when integrated into the watch. We tested technical functionality and usability. In the following, we describe the conceptual design and the implementation of the final prototype of LightWatch.

2.1 Conceptual Design

The requirements on the system are, that, it must provide the function to measure, adjust, and display a user's exertion level. It must be integrated into a common wristwatch, everyday suitable, and easily usable while being worn. The conceptual design of Light Watch is as in the following. A user can measure his or her exertion level with a heart rate sensor. The exertion level is displayed by circular arranged LEDs on the bezel of the watch. The lowest exertion level is indicated by the first LED on the 12 o`clock position. The mapping of LEDs to exertion levels goes clockwise from low to high. The higher the exertion level, the more LEDs are illuminated clockwise. A user can adjust the measured value by pressing the LED that represents his or her perceived value.

In the following, we describe the interaction concept. After switched on, the watch is in idle state. The user can open the menu by pressing the bottom area of the LED ring, i.e. about the six o'clock position, for at least 2 seconds. Three different areas of 4 LEDs each light up in red, green, or blue (see **Fig. 1**). Within the next 7 seconds, the user can press one of the three areas to choose between the options *measure heart rate* (red), *show latest value* (green), or *quit menu* (blue). The system confirms a user input by switching off the LEDs in the not-chosen areas. After a user has chosen the red area, he or she can place a finger onto the heart rate sensor. For each measured pulse beat, an LED lights up red. If 12 pulse beats have been measured, the calculated exertion level is displayed in that the according LEDs light up white. Within the next 4 seconds, the user can adjust the value if he or she perceived the exertion differently. If he or she does not react, the value will be saved after 4 seconds. To adjust the value, the user presses the according LED. The input is confirmed in that the LEDs representing the entered value light up white. After 2 seconds the input is saved. If the user chooses the green area, the latest value that was captured will be displayed through

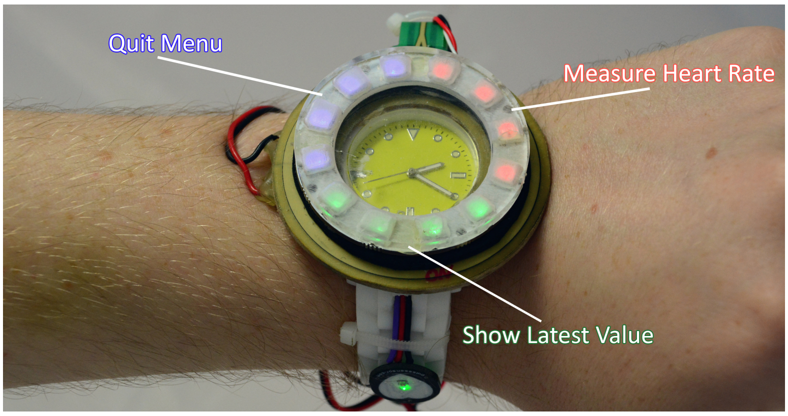

Fig. 1. A user wears LightWatch: Light menu is opened and heart rate sensor is enabled.

white illuminated LEDs. Whenever a user does not react for 7 seconds after opening the menu, the watch will return to idle state. The blue option offers a quick exit in case the user does not want to wait for 7 seconds.

2.2 Implementation

For the implementation of LightWatch, we used an off-the-shelf analogue plastic wristwatch. Following, we describe the design of LightWatch from top to bottom. On the top of the watch there is a cover made from a 6mm thick pane of acrylic glass that we cut with a laser cutter. Indentations for the underlying LEDs and circuit board were laser etched and the glass was cut to round shape. It protects the underlying delicate electronics from forces of the user when he or she makes inputs by pressing the surface of the watch. Beneath the cover glass we mounted an Adafruit NeoPixel 12 RGB LED ring. It carries 12 serially addressable RGB LEDs on a common circuit board. When the LEDs are illuminated, the etched glass atop the LEDs diffuses their light. A ring of 2mm thin foam rubber flexibly connects the LED ring to the underlying HotPot rotary potentiometer. It encodes the position of pressure that a user puts on the glass to an analogue resistance.

The rotary potentiometer is taped down to a ring of pressboard by double-sided adhesive tape. The pressboard was laser cut and glued to the watch case. The pressboard ring provides a stable base to the rotary potentiometer and transfers applied forces to the watch case. The watch case and watchstrap were modified from a common analogue plastic wristwatch. We drilled and grinded holes to fit a connector and to route cables to the outside. The watchstrap carries a 1000mAh LiPo battery and a heart rate sensor, the Sparkfun Pulse Sensor Amped. In lab tests we found that the heart rate sensor does not provide reliable measurements on the wrist, but on fingers. Therefore, we mounted the sensor on the watchstrap. The heart rate sensor is attached to the lower watchstrap by a cable tie, and faces upwards. It measures the user's heart rate when a finger is applied (see **Fig. 1**).

The watch case houses the original clockwork and an ATtiny85V-10SU microcontroller. We soldered all connections directly or via stranded wire to the microcontroller. The microcontroller processes data provided by all sensors and drives the LED ring. Embedded into the side of the watch case is a female pin strip with 0.1 inch (2.54 mm) pitch. It leads out the connections needed for in system programming (ISP) the microcontroller. Via the pin strip the watch can be programmed and the collected data can be downloaded to a computer.

3 Discussion and Conclusion

In this paper, we presented LightWatch, a light information display for personal exertion that is integrated into a common analogue wristwatch. Our prototype serves as a proof of concept that the integration of a pressure-sensitive light display into a common wristwatch is possible without interfering with the functionality of the analogue watch itself. The major advantage is that a user can keep using his or her preferred watch, that is enhanced by further digital functionality. Wearing another device like a technically looking smart watch that does not meet the user's fashionable requirements is not needed. We think that a regular wristwatch that is expanded in a way like LightWatch is a promising approach for a useful everyday companion that can be used for various applications. These could e.g. be a display for physical activity, fluid intake, or medicine, as well as a reminder for dates.

The LightWatch prototype we presented in this paper is limited in that it is in an early development status. In the next step, we want to conduct user studies to investigate the user experience and practicality of LightWatch in real life. Therefore, we need to technically refine the prototype, i.e. to thin it, to hide all cables and the battery, and to improve its visual appeal.

4 References

1. Cheng Xu and Kent Lyons. 2015. Shimmering Smartwatches: Exploring the Smartwatch Design Space. In *Proceedings of TEI '15*. ACM, 69-76.
2. Jutta Fortmann, Vanessa Cobus, Wilko Heuten, and Susanne Boll. 2014. WaterJewel: design and evaluation of a bracelet to promote a better drinking behaviour. In *Proceedings of MUM '14*. ACM, 58-67.
3. Robert Xiao, Gierad Laput, and Chris Harrison. 2014. Expanding the input expressivity of smartwatches with mechanical pan, twist, tilt and click. In *Proceedings of CHI '14*. ACM, 193-196.
4. Simon T. Perrault, Eric Lecolinet, James Eagan, and Yves Guiard. 2013. Watchit: simple gestures and eyes-free interaction for wristwatches and bracelets. In *Proceedings of CHI '13*. ACM, 1451-1460.