Demo: Hybrid Watch User Interfaces: Collaboration Between Electro-Mechanical Components and Analog Materials

Figure 1: Electro-mechanical watch hands and dial transform and jointly form new hybrid user interfaces, leveraging their respective strengths.

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Abstract

We introduce programmable material and electro-mechanical control to enable a set of *hybrid watch user interfaces* that symbiotically leverage the joint strengths of electro-mechanical hands and a dynamic watch dial. This approach enables computation and connectivity with existing materials to preserve the inherent physical qualities and abilities of traditional analog watches.

We augment the watch's mechanical hands with micro-stepper motors for control, positioning and mechanical expressivity. We extend the traditional watch dial with programmable pigments for non-emissive dynamic patterns. Together, these components enable a unique set of interaction techniques and user interfaces beyond their individual capabilities.

Author Keywords

Wearable computing; programmable material; E-ink; actuation; analog watches; hybrid watches; smartwatches.

Figure 2. Cooperation. Steerable physical hands are used for menu selection to optimize power and interface responsiveness.

ACM Classification Keywords

H.5.2. User Interfaces: Input devices and strategies, Interaction Styles.

Introduction

Research studies [5, 8, 9] point to challenges in smartwatch adoption, due to dissatisfaction with the significantly different shapes, aesthetics, and looks of smartwatches, and the perception of smartwatches as utilitarian "wrist-worn electronic devices" rather than aspirational fashion accessories and jewelry.

This work focuses on computational capabilities that can co-exist with analog watch aesthetics and conventions. We build our contributions on the many creative approaches to novel display and output for wristworn devices [1, 3, 4, 6, 7, 10, 11, 12, 13, 14, 15, 16, 17]. Shimmering Smartwatches may, however, be the project that is closest in spirit to ours [18]: "*an opportunity to create devices that provide smartwatch functionality that do not use the small high resolution graphical displays often associated with smartwatches.*" We contribute a complementary approach to further broaden the design space for computational *analog watches*, where we innovate with existing analog watch components through computational control (See Figure 1). We augment the watch's mechanical hands with micro-stepper motors for control, positioning and mechanical expressivity. We extend the traditional watch dial with programmable pigments for non-emissive dynamic patterns. Our main contribution is how we use these two programmable materials to coordinate and trade responsibilities in novel hybrid watch user interfaces (UIs) that symbiotically leverage the strengths of physical hands and dynamic watch dials.

Cooperative Hybrid Watch Interfaces

Analog watches were designed to show time. However, through connectivity and computation, additional visualizations are relevant today. The ability to reconfigure the position of the hands mechanically and reprogram the pigments in the analog dial, allows us to adapt the interface along several dimensions.

Distributing UI between Pixels and Physical Hands. Pixels and physical hands cooperate to create optimal user interfaces by distributing responsibilities across different display mechanisms.

Deictic Reference: Hands Pointing to Pixels. Saving power and performance by using the hands to point to different parts of a static E-ink screen. (See Figure 2)

Prioritizing Visual Contents: Hands Avoiding Pixels. When the dial needs to display prioritized content (e.g. incoming notification), the hands are moved out of the way, or collapsed, to minimize occlusion. (See Figure 3)

Prioritizing Mechanical Hands: Pixels Avoiding Hands. We may wish to preserve the position of the mechanical hands, while presenting prioritized contents on the dial. The notification icons could simply choose a suitable location on the dial, e.g., based on the amount of unoccluded space.

Intentional Occlusion: Repurposing Graphics. Using the hands to temporarily "hide" visual elements.

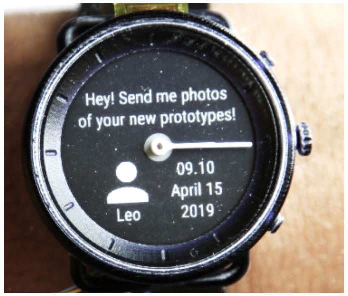

Figure 3. Content-awareness. The hands fold out of the way for text.

Figure 4: Visual vibration. The physical hands vibrate on a new message.

"The UI updates" by moving the hand between occlusion of all options except one on a static screen. This could address hardware limitations, e.g., refresh rate or transition quality.

Fusion: Matching appearance, shape and color. UI-elements can be constructed by aligning the hands with screen shapes, such that they become part of the geometry.

Mechanical Expressivity: Physical Motion. Visual mechatronic effects can be used as a complement or alternative to digital displays. Given our visual perception system's sensitivity to motion in the periphery, this provides an interesting opportunity to attract the user's attention with motion when light or sound is inappropriate or insufficient. (See Figure 4)

Tense: Past, Present or Future. The information can be displayed as a reflection or as a prediction at different scales. For example, reviewing fitness activity over the last 12 hours, or to preview the calendar for the next 12 hours. See Figure 5.

Scale: Temporal and Semantic. The interface can also reconfigure to adapt the presentation to different scales, presented as relative visualizations to the physical hands.

Hybrid Watch Implementation

Our proof-of-concept implementation contributes interactions with programmable pigments in a dynamic watch dial overlaid with steerable physical hands.

Programmable Pigments for Dynamic Dials

In this work, we leverage high-resolution e-ink displays as reprogrammable dials. For our dynamic dial, we chose a round panel from E-ink [2], which has a center hole to allow the combination with analog watch hands.

Steerable Hands: Electro-Mechanical Movements

We leverage micro-stepper motors for bidirectional rotation through electrical pulses. We repurposed PCB-mounted stepper motors, for hour and minutes, from a Withings Activité watch. Through experimentation, we identified a suitable pulse width of 2 ms, and an inter-pulse timing of 5 ms. The minute and hour hands have 120 and 90 steps per revolution, respectively. We designed a housing for the components, which we 3D printed for one prototype and machined out of aluminum for another. They both use an additional flexible PCB with three tactile switches connected to mechanical buttons on the housing. We use a a Bluetooth Low Energy-enabled (Nordic nRF8001) microcontroller (Atmel ATmega32U4) from Red Bear Labs (Blend Micro), to interface with the buttons, control the stepper motors (magnet wire to left, common, and right pins) and to control the E-ink display. The microcontroller is running our watch application framework written in C++ that we developed to enable rapid exploration of capabilities and interface concepts.

Conclusions

This work leverages opportunities for transformation and cooperation in a hybrid watch user interface, using two complementary dynamic materials; steerable hands and programmable pigments. We believe that this approach enables new opportunities and advantages for innovating with existing materials to

Figure 5. A dynamic weather forecast is displayed across the bezel and updated every 10 minutes.

preserve inherent qualities and abilities of analog devices.

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