Quietto: An Interactive Timepiece Molded in Concrete and Milled Wood

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ABSTRACT
We introduce Quietto: an interactive timepiece made of molded concrete and milled wood. It shows upcoming daily schedules and the time through the quiet, ambient motions of a clock hand and light through the concrete touch interface. The results of an in-field user observation of 10 participants over 3 days showed the possibilities of using concrete as a unique and attractive material for designing a tangible interface due to its unexpected haptic feeling. We also found that Quietto provides an intuitive and effective representation of its users' daily schedules and can be used as a private, personal device. Through its distinctive design, Quietto can provide a new way of understanding scheduling through its concrete texture and amusing interaction qualities.

Author Keywords
Concrete; Interactive Timepiece; Schedule; Ambient

ACM Classification Keywords
H.5.2 Information interfaces and presentation: User interfaces—Input devices and strategies, interaction styles.

INTRODUCTION
In the creation of interactive devices, the material and appearance are one of the significant factors [9], and their sensorial properties influence the product experience [1, 10, 6]. In particular, as recent smart devices require exquisite visual-tactile interaction with users, we can see that the unique texture and aesthetics quality represented by the materials have a significant relationship with the formation of constant value and attachment to the product [17]. Additionally, the fabrication of some products' forms was attempted with wood [15] or fabric [7]; thus, those seem to add new sensibility to the products through harmonizing naturally with the furniture in the house and providing the users with pleasant interactive experiences. Within this trend, concrete in particular is often used in designing everyday products, such as clocks [13] and lamps [4], due to its unique color and texture. Moreover, concrete has been applied in interaction with users with a feature that represents traces of moisture [16], however, in the field of HCI, making prototypes with concrete through a professional mold-making process has rarely been studied.

Furthermore, the need to increase crafting quality by applying new materials is very important because it is directly related to the investigation of creative interaction with materials and aesthetic taste through those materials [2]. In addition, the outer material sensibility of smart devices may add more value in terms of their user interaction when the shape of the device reflects conventional and familiar product forms [12]. This aids in providing digital information to promote harmony with a user's daily environment, rather than showing information on a digital display. One example is daily schedules, which are still mostly represented on a phone screen or monitor display. Thus, intuitively representing the remaining and blank time before upcoming appointments is limited. Previously, there were few studies on representing time and schedules through the conventional form of a clock; however, these cases were dependent on a light display [7] or a computer monitor [5]. Other cases have applied tangible interaction for snoozing time [18] with a form that can balance by itself or with LEGO blocks for schedule inputs [11]. Accordingly, there is still a need to design a tangible interaction with time and schedules with an engaging concrete material along with representing time in the form of a conventional timepiece.

We propose a novel interactive concrete timepiece called Quietto and discuss the new experiences it can create by representing time and schedules through tangible interaction.

Figure 1. Five Quiettos: representing current time

QUIETTO DESIGN
Quietto is an interactive desk-top timepiece molded in concrete and milled wood that represents users' daily schedules by the physical movement of a clock hand and

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light using real-time data retrieved from Google Calendar. The main functions and features of Quietto are as follows:

- Tangible interaction with time and schedule: Quietto design began with understanding the purpose of watching clocks. We considered that the purpose is not only to know the current time, but also to make plans after that. Because of this, we represented the schedules through the interval between the current time and the upcoming schedule. In spite of showing the entire schedules, we focused on representing the intervals through a tangible interaction. Through this intentional restriction of a function, also called as counterfunctionality [14], we wanted to identify new ways of understanding schedule. Consequently, Quietto shows the time remaining from the current time to the upcoming events through physical movement of the hour hand and an LED light.
- Concrete and wood interface: Our major focus was to represent the movement through the material itself (not through a button), in order to provide a natural experience of controlling the physical movement of time. Thus, in the process of selecting the material, we chose a concrete material that has a soft feeling to the touch, creates a visual sense of stability, and of course, matches well with the wood. Therefore, the cast concrete manufactured through a mold and the natural wood made by CNC machining are used as a touch interface for interaction with users.
- Quiet & ambient interaction: Quietto brings an ambient interaction [8] with the user through the quiet movement of a stepping motor and a subtle LED light that glows from behind the wood. This works in harmony with a desk-top environment.

Interaction Technique

Quietto represents the current time through the hour hand on the iron rod in the middle of wood and the minute hand in a transmitted LED light displayed on the circular rim of the wood (Figure 2, a). If the user touches the top of the concrete, the hour and minute hands move to show the start time of upcoming appointment (Figure 2, b). If the user maintains the touch for more than two seconds, Quietto shows the entire schedule for the day through the green LED light (Figure 2, c). When the user releases his or her hand, the hour and minute hands move back to the current time (Figure 2, d). In addition, Quietto gives notifications through the LED light fifteen

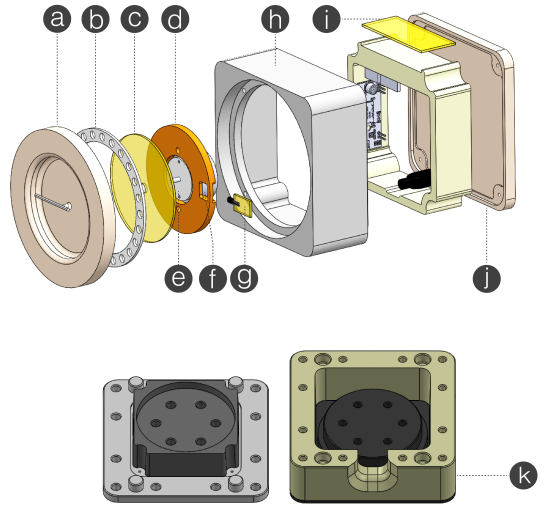

Figure 3. A detailed structure of Quietto (a) Milled wood, (b) Bracket for LED, (c) Copper plate, (d) Bracket for stepper motor, (e) Circular acrylic plate, (f) Stepper motor, (g) Hall sensor, (h) Concrete body, (i) Copper plate, (j) Backplate, (k) Plastic mold

minutes before the start of the upcoming schedule. Quietto automatically receives information from Google Calendar every five minutes. If the user wants immediate updates, touching the inside of the circular wood (Figure 2, e) causes Quietto to receive real-time data from Google Calendar.

Implementation

Hardware

We first made the concrete body from a mixture of water and ordinary Portland cement (OPC). The mixture was poured into the four-layer CNC-machined plastic mold (Figure 3, k) which was fabricated for making a 3-D structural concrete form. When designing the mold, we added a one-degree gradient to the assembly parts, and a lubricant was sprayed inside of the mold for easy removal of the solidified concrete form (Figure 3, h). At the center of the concrete body, we machined the natural wood into a circular shape (Figure 3, a). To place the LED stripe, grooves were carved into the back of the wood. A white 2T acrylic plate (Figure 3, b) was inserted between the wood and the LED stripe for uniform lighting. To implement the capacitive touch sensing on the concrete and wood, we cut out two copper plates (Figure 3,

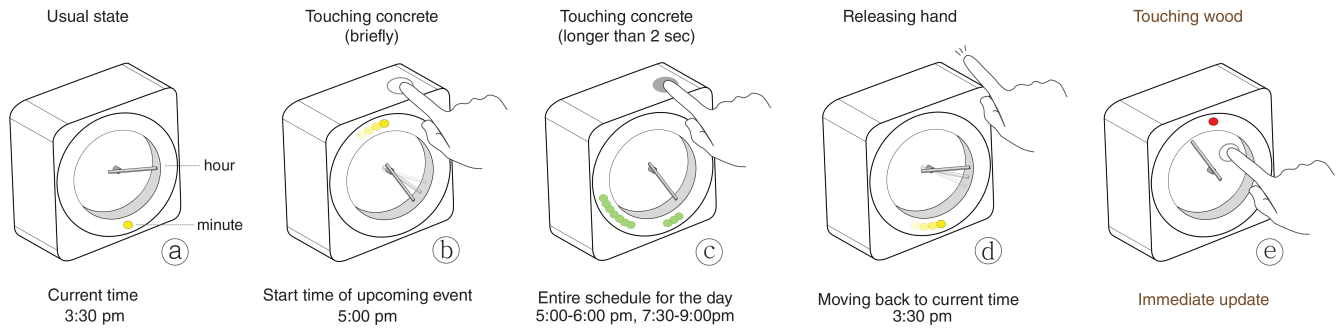

Figure 2. Interactions of Quietto

c, i) into proper shapes and placed them on each material. Then, 2.4-mega-ohm resistors were connected with the copper plates individually and calibrated for each Quietto. To hold a stepper motor (Figure 3, f), we made a circular bracket (Figure 3, d) with a 5T acrylic plate and drilled two screw holes into it. Because the hour hand has to be positioned correctly to display accurate time, we made a tiny circular acrylic plate (Figure 3, e) with two magnets and fixed it upon the axis of the stepper motor. Accordingly, when the stepper motor rotates, the magnets rotate together. As a result, the hall sensor (Figure 3, g) in the bracket detects the location of the magnets and recognizes the correct position of the hour hand. We used Arduino Yun, which is Wi-Fi ready, to obtain each user's Google Calendar data in real-time via the Internet. A stepper motor driver was placed on the inside of the concrete body. Lastly, the backplate (Figure 3, j) of the Quietto was finished with the CNC-machined wood.

Software

When Arduino Yun is booted up, it initializes its application processor (AP) and microcontroller unit (MCU). The AP, which is based on the Linux system, connects to the Internet via wireless connection, and it retrieves the current time and users' daily schedule information from the server. Meanwhile, the MCU detects the signal of the hall-effect sensor to calibrate the correct position of the stepper motor, which holds the hour hand. If the calibration has been conducted, the MCU is ready to obtain the current time and the user's daily schedule information. After that, it rotates the hour hand to the current hour and turns on the LED light to the current minute. Capacitive touch is implemented by the calculation of difference for a resistor-capacitor time constant. A send pin is connected with the 2.4MΩ resistor and goes into the two receive pins, which are attached to two copper plates individually. This causes a send-receive delay that the MCU detects; the MCU then recognizes the touching status of each copper plate. To reduce the interference between two copper plates, we calculated the average by finding the sum of samples in every 100 ms.

Data logger

When the user interacts with Quietto through touch, statistical data is created and sent via Arduino Yun to our database server. Each data record is composed of a timestamp, unique identifier, touch location and duration. If the duration is too long (>20000 ms) or short (<100 ms), we classify the record as invalid data and reject it from the statistics. The statistical data is collected in real time.

USER STUDY

We conducted an in-field study to explore the value of Quietto when used as a table clock. Through this experiment, we wanted to investigate the following: (1) how does the visual and tactile feel of concrete perform as a touch interface? (2) how does the tangible interaction between the current time and daily schedules affect a user's scheduling?

Ten people in their twenties (aged 22-26, 6 males and 4 females, P1-P10) participated. We recruited them because they used Google Calendar and worked in an office. Five identical Quiettos were built for the experiment over a period of 5 weeks. To extract the true user experience, we performed in-field user observation over 3 days rather than an in-lab study [3]. The day before the beginning of the experiment, we visited the participants' offices to install and test the Quiettos. Consequently, they were able to make full use of the Quiettos without failure during the experiment. The interview was conducted for 20 minutes every evening after the completion of more than 8 hours of the participants' daily schedules. The interview questions mainly focused on overall usability, feeling and the experience of interaction with the concrete and the advantages and disadvantages of the new representation of a digital schedule through Quietto. The data collected were in total 586 minutes, and all of the data were transcribed. They were analyzed using the affinity-diagramming method and through an iterative process of grouping by our research team. Some issues were culled according to the reports of the lead participant.

FINDINGS

The frequency of the participants' touch on the concrete body for checking schedules was a total of 607 times over 3 days, and on average, participants used the Quietto 20 times per day. In comparison with the number of touches in the first day (an average of 39 times), users touched the Quietto 16 times in the second day. These usage logging data were utilized to supplement the interview transcription.

Concrete as an Attractive and Unexpected Tangible Interface

We explored how participants used the concrete touch interface of Quietto, and we were able to find common points. Seven participants stated that the experience of touching concrete was unexpected and engaging. P9 said, *"When I saw the concrete with my eyes, it looked rough, but when I touched it, it was very soft such that I wanted to touch it again."* P3 mentioned, *"It (concrete) is somewhat contradictory when seen. It looks rough but is very soft. Also, it looks rather heavy, but it is not heavy."* In particular, P5 stated, *"It is the complete opposite of what I thought. What I thought was that it would feel like rough and cool, but it wasn't. It was soft and warm."*

We thus identified that the sensorial and interpretive properties of concrete material [6] can provide new touch experiences through its unexpected but positive texture. In accordance with this point, five participants mentioned that the touch experience of the concrete was notably different from the touch screens or plastic touches that were mainly used as materials for conventional digital interfaces. During the interview, P3 stated, *"The screen and body of a mobile phone is unnatural, and it feels like it will get dirty when I touch it frequently; however, concrete contains a natural sense of feeling so that it feels like it will not get dirty even when I keep touching it."* In addition, four participants mentioned the stable feeling with regard to the concrete's

appearance of being heavy. P10 said, *"If the product is too lightweight, then it feels like it is plastic, but Quietto was different. It had a stable feeling by providing a courteous feeling."*

In line with a previous study [16], we identified the combination of concrete and digital technology has increased user's curiosity about the device, in particular it aroused participants' interest on touch interaction with the device. In addition, our findings have implications about the possibility of concrete could be utilized as new tangible interfaces through its positive visual and tactile quality.

Intuitive and Effective Representation of Daily Schedule

We heard from nine participants that it was a new experience when Quietto showed the digital schedules through the representation of physical time intervals in the form of an analog clock. Specifically, P8 mentioned, *"The way that Quietto informed me of my schedule was new because it was not a function that an original clock has. It was a calendar of a day. …omit… Within a day, it was good to check the starting point of today's schedule from here."* She also stated that she could immediately notice that the (upcoming) appointment was far away if the clock hand rotated significantly and that there would be an appointment soon if it rotated a little. Additionally, P2 mentioned, *"Digital calendars feel like the time flow seems to be interrupted because the schedules are aligned in cells, but through Quietto, I could identify at a glance when my appointments were during the day and when the free time was because it is represented continuously."* This finding has a common point with a previous study [5] that the analog representation of schedules was helpful to recognize the schedules. In addition, participants gave their opinions about effective time management and checking schedules through Quietto. Particularly, seven participants answered that they managed time more effectively because they could finish their obligations on time. Also, five participants mentioned that Quietto helped them to remember forgotten obligations and perform them promptly.

Private and Ambient Personal Schedule Clock

We expected there could be privacy issues when personal schedule information was displayed at a public office (working) space, even though it was located on one's desk. On the contrary, all the participants stated that they did not feel that their privacy had been violated during the 3 days of use. Seven participants said this was because the details of their schedule were not shown on the device. P9 stated, *"The schedule can be seen, but I didn't care because it (Quietto) did not show the details."* We thus learned that Quietto could be a private device displaying information that only the user could recognize through the indirect representation of personal scheduling information.

DISCUSSION & IMPLICATIONS

Our findings from the field trial implied that Quietto's unique finishing and the experience it evokes gave a lifelike feeling to the clock when interacting with time and schedules, and this feeling was expanded due to the concrete's engaging texture when touching it. Along with this, easy and simple identification of the time of an upcoming schedule showed the possibility of providing a closer interaction between the product and user beyond the simple time-telling function of a clock. Based on the results, we propose the following implications for improving Quietto and opening a new design space using concrete. First, if the schedule is delayed or needs modification, without changing the schedule on Google Calendar and through the input of adjusting the schedule time by slightly moving the hour hand with a finger, Quietto could be an improved interactive scheduling timepiece. Second, the concrete used as the touch interface presents a new opportunity for various fields including architecture and design. For example, in a new building, concrete walls are used as an interior. They could display touch-type switches to turning light fixtures on or off; in this way, they could be designed or modified to be a new type of interior. Moreover, based on the nine participants' positive comments about the design that it combined concrete and wood, blending concrete and wood in pieces of furniture could also create a novel interface to control home appliances.

CONCLUSION

We introduced Quietto, an interactive desktop timepiece made of concrete and wood that represents users' daily schedules through the physical movement of a clock hand and light. Its appearance was completed through the combination of concrete body cast with a carefully designed mold and CNC-machined circular timber. The result of an in-field user observation of 10 participants over 3 days presented a new opportunity to use concrete as an attractive material for designing a tangible interface due to its unique tactile feeling. In addition, through the physical representation of a daily schedule and time, Quietto helped users comprehend their schedules more intuitively and manage them more efficiently. Simultaneously, it played a role as a private device. Through its distinctive appearance and interaction, Quietto could open a new design space and provide a new way of understanding time through its concrete texture and engaging interaction qualities.

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