Cool Interaction with Calm Technologies - Experimenting with Ice as a Multitouch Surface

Antti Virolainen
Nokia Research Center
Itämerenkatu 11-13
00180 Helsinki
Finland
antti.virolainen@
nokia.com

Arto Puikkonen
Nokia Research Center
Visiokatu 1
33720 Tampere
Finland
arto.puikkonen@
nokia.com

Tuula Kärkkäinen
Tampere University of
Technology
P.O. Box 589,
33101 Tampere
Finland
tuula.karkkainen@
gmail.com

Jonna Häkkilä
Nokia Research Center
Yrttipellontie 6
90230 Oulu
Finland
jonna.hakkila@
nokia.com

ABSTRACT
In this paper we describe our interactive ice-wall installation, which is a multi-touch surface built from ice. Our demo seeks to stretch the boundaries of current ubiquitous computing systems by trying out a new material, which embeds itself to the environment – here, outdoors in a snowy winter. In addition to the function of the interactive installation, where we show that ice as a material can be used for such purposes, we seek to offer an inspirational aspect to the design of ubiquitous computing systems. We also present the feedback collected from 33 surveyed and 10 interviewed users who interacted with the system.

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General terms: Design, Experimentation, Human Factors.

Keywords: Interactive surfaces, multi-touch interaction, prototyping, ice, user studies

INTRODUCTION
Interactive surfaces, which have emerged as user interfaces for numerous different commercial and research applications during the last years, are bringing computers closer to our everyday surroundings. This is especially happening in comparison to the traditional desktop style set-ups. Weiser's vision about ubiquitous computing places computing to the background, embedding it to the everyday objects and environments, where it will disappear without distracting and requiring frequent attention from the users [10].

Interactive surfaces and pervasive displays facilitate some of the core ideas of ubiquitous systems, as they can be embedded to everyday objects and be used e.g. as table surfaces, walls or doors. Examples include set-ups like the Gate Reminder, where a display on a door is used to deliver context-aware reminders [4]. Interactive surfaces can also be used to facilitate social interaction and collaboration, as these surfaces are typically rather large and allow several people to interact simultaneously, e.g. [5, 9].

Ubiquitous computing is nowadays closer to fulfilling Weiser's promise, as areas such as implicit input methods, distributed output, context-aware computing, and the integration of physical and virtual worlds emerge, as discussed in [1]. However, a lot remains to be done before we can say we interact with truly pervasive systems with seamless integration both in functionality and design.

Bringing computing to the periphery, where it will appear as an ambient system requiring attention only when needed [7], involves not only engineering but also aesthetics design to succeed. This approach has been considered already in some concepts around public and ambient displays and smart furniture. Chandler et al. point out the dominant use of a flat panel LCD or OLED technology and how the commercially driven application domains are not aligned with the design principles of calm technology, and present their Firefly blended display prototype, where lighting elements are dynamically controlled and where these smart pixels can be arranged to form displays taking different physical shapes, e.g. here a 'light curtain' on the window [2]. Video projection technologies have also been used to create displays which adapt to the shapes of the environment, such as corners and walls, expanding the design space of interactive surfaces beyond a single panel approach [3].

Some experiments of using water as a display in different forms does exist. Rakkolainen and Palovuori described an interactive FogScreen display using laser scanning based tracking on a display made of flowing air and visible fog on the center of air flow [11]. Heiner et al. presented an ambient display formed by air bubbles rising up tubes of water [12]. Our approach introduces a novel design for an interactive surface. We have implemented a multi-touch screen using a material which has been very little (or not at all) used in pervasive computing – ice. In this paper, we present our installation demonstrating the system, and our collected user feedback on it. We provide our experience of building

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a multi-touch display from an unconventional material, and our views of what should be taken into account when designing an interactive ice installation. In addition, we seek to offer an inspirational viewpoint on how interactive systems could be integrated to everyday life environments.

Figure 1. Building the screen. A) Jointing, B) Stacking, and C) Finishing the blocks

INSTALLATION

The Screen

The screen was made of ice blocks which were stacked to construct a wall (Figure 1). We used natural ice blocks, which were picked from a frozen river. However, if natural ice had not been available, artificial ice, often used for ice sculpting, could have been purchased. We exploit an external company's service to pick up the ice and to help with the building process. (Picking natural ice from a frozen lake or river is a highly dangerous process and should be left for the experts only!). Ice was cut approximately to 50x50x25 cm blocks that were rather heavy, but still movable by two persons. According to our experience we would not recommend using bigger block without machinery for lifting and stacking the blocks. However, the smaller each block, the more there will be visible joints on the screen.

A good tool for cutting ice was a chain saw (requiring an expert user), and also several custom made ice cutting tools were useful when sculpting the ice (Figure 2). Ice blocks were glued together by applying snow and water on the joints of the blocks, which made the wall solid in the freezing weather. Our installation was built from 12 blocks, which made its measures to be approximately 1.5x2.0 meters.

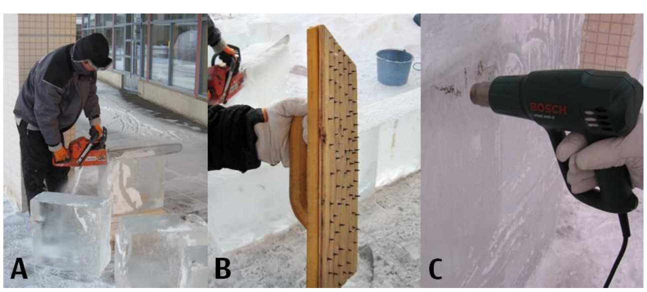

Figure 2. Useful tools for building an ice wall. A) Chain saw, B) tool for finishing, C) Hot air gun

After the wall was set up, it needed finishing. It was roughly done with a custom made ice-sculpting tool (Figure 2, B) and more precisely with a planer (Figure 1, C). After the finishing, it was still obvious that the transparency of the wall was not uniform enough for a decent camera tracking. This was due to the frost on the surface of the ice blocks, partly because of the moisture from the air and partly because of the roughness of the finishing. The problem was solved by melting the surface slightly with a heat gun (Figure 2, C) which made the screen surface clearer and the translucency became much more even.

The Tracking System and the Application

Our demo was implemented using rear-diffused illumination multi-touch tracking technology. The screen was illuminated by large near infrared illuminators often used with security camera systems. A critical factor for the setup to function properly was to get a relatively even illumination for the entire screen. This was partially accomplished by using two illuminators placed in the rear of the screen at a distance which suited best for illuminators beam width.

Figure 3. IR camera image, A) Users palm, B) imperfections of the surface, C) Joints of the blocks

Touch events were tracked by using a Web camera which streamed VGA resolution video with a 30 frames-per-second frame rate to a computer. The image processing was done by Community Core Vision [6] multi-touch tracker software and the demo application was written in Java based Processing environment [8]. The demo application was a simple visual multi-touch demonstration where every tracked touch point produced flames which followed the hands touching the ice surface while slowly blazing away (Figure 4). Our assumption was that because of the roughness of the surface compared to, for instance, a traditional glass surface we should not overrate the potential tracking performance. Instead of trying to track individual fingers (like usually with the interactive multi-touch surfaces) we set limit to our requirements to track hands only. This assumption proved to be correct and it turned out that a successful finger tracking would have been extremely difficult (see Figure 3) to achieve with an ice surface.

The illumination of the screen was not fully sufficient and a greater number of illuminators would have lead to a better result. The tracking sensitivity had to be adjusted to be slightly too sensitive on the center of the screen to make the screen responsive enough all around. Despite the slight problems with the illumination, the screen functioned well enough to be used with bare hands. Some of the users wearing black gloves did experience sensitivity problems, and in general, the color of the gloves did have an effect on the tracking sensitivity, which should be taken into account with future open-air installations.

Projection

We used a conventional office projector with XGA resolution and 2000 ANSI lumen brightness. The intensity was enough for low ambient light conditions (after sunset), but in a bright environment a more powerful device might have been needed. The heat radiation produced by the projector was a concern, but the projector proved not to melt the ice at all. Another concern was how the projector would survive in cold open air. During the experiment, the outside temperature (-15° C) was far below the device's recommended operating temperature range (+5 - + 35° C). We located the projector inside a plastic box with openings for the cables and the lens and placed a thermometer inside the box to monitor that the temperature stayed in the range. As presumed, the diffusion of the projection was far from perfect from the ice surface, and a clear white blob was produced by the projector on the center of the wall (Figure 4). The effect was notable but not too disruptive.

Figure 4. Interaction with ice wall

User study

Study Set-Up

The installation was set up in Oulu, Finland in January 2010, in the campus area of the local university. As the installation was available for public use, we collected feedback from altogether 33 participants. The installation was available for one afternoon. The feedback on the user experience of the wall was gathered with three quantitative questions on a 5-point scale. We received feedback on how reactive and appealing the system was, and how well it integrated to the environment. Furthermore, the users who were willing were also interviewed for gaining more detailed feedback on the experience. The interview prompted the reasoning behind the answers to the quantitative questions, general perceptions of the installation, and three demographic questions. Altogether 10 (5 male, 5 female, age 21-47) participants were interviewed.

Findings

The feedback collected from 33 users show that the installation was rated rather high in appeal and responsivity, but most of all, its connection to the to the environment was perceived as very strong (Figure 5). The interviews also supported this viewpoint, revealing that the uniqueness of the installation was acquired through the new material - bringing a piece of nature and combining it with technology was an exceptional thing which interested people and brought them delight. Although this finding was not a surprise but rather as a confirmation of our own conception, it supports the view that people do pay attention to the holistic design, and designing according to the environment is an important factor:

It suits [well] here in the North since it has ice elements, and light is what you need during this dark season (#8)

It's not like putting plastic… just ice, nature, ice (#10)

Moreover, the holistic design aspect was emphasized in a comment which pointed out that the light patterns created a somewhat negative contrast being not similarly as natural element as the material itself (user #5).

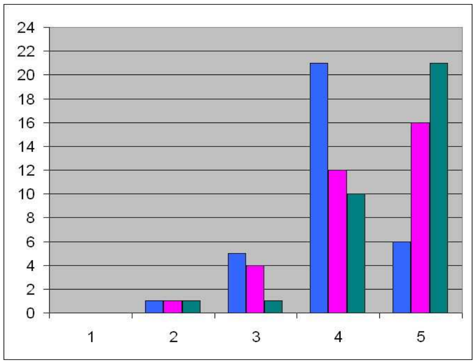

Figure 5. Feedback collected from the users (n=33) trying out the installation: How reactive was the installation? (blue); How appealing was the installation? (pink); How well does the technology integrate with the environment? (green)

In addition, the interviews highlighted the delight aspect of the design, which was explicitly mentioned by six interviewees (#1, 4, 5, 6, 7, 10). The installation was for instance mentioned to "*provide a small piece of leisure time in between all the everyday chores (#6)*. Another aspect frequently mentioned was that the interactivity of the installation was perceived appealing (#2, 3, 7, 8, 9, 10). The interactivity was commented to create curiosity – in fact trying out they had already been recommended (#7). On the other hand, the feature was perceived both inviting (#10), but also potentially something which people would not *'dare to touch'* (#7). Three interviewees (#4, 5, 8) also highlighted that ice as a material provided further possibilities for playing around with the form factor, and users came up with ideas such as using a heart shape display or ice tunnel (#8). Moreover, larger and multi-piece installations were suggested (#5, 6), as well as utilizing the icewall for games, or board where passer-bys could leave drawings (#6).

For the user study perspective, lessons learnt related to the extreme (winter) conditions emerged. The collection of the user feedback in such conditions is a challenge, as providing written feedback *in situ* is practically impossible. In our case, we used the collecting beads in the ice cups for scores next to the icewall, and the interviews were carried out inside the building near by.

DISCUSSION

The greatest challenge with an interactive ice surface is to get the tracking to work sufficiently. The tracking resolution is going to be significantly lower compared to traditional surfaces, so that the interactive application should be designed in such a way that the tracking of palms is enough. Getting reliable finger tracking for an ice surface seems to be challenging.

Projecting content on the ice surface has many differences compared to projecting on traditional surface materials. Properties of the ice vary and the cracks, joints between the blocks and frost will have a great effect on the projected content. The diffusion from the ice surface will be heavily blurred which softens the edges, blend colors and generally dispels the details. Therefore when designing interactive applications, small details e.g. text with small font or small graphical objects should be avoided. We recommend using large contrast with the graphics and also not to pay too much attention on the fine-tuning of the parameters like hue and opacity of the colors, because it tends to be needless. Despite the challenges, the imperfections of the natural ice will have interesting and artistic effects on the projected content and thereby every installation will be unique.

An installation in the freezing open-air weather is a natural place for an ice wall. Surprisingly, an ice surface can also be installed indoors without concern of rapid melting of the screen. Large blocks of ice will melt relatively slowly in normal indoors conditions and the wall can easily stay operable from six to eight hours. The greatest challenge for an indoor installation is the continuous clarifications of the ice which will dilute the diffusion of light and require periodical changes on the system parameters. We see that interactive ice surfaces raise attention among people and surfaces made of natural material like ice could have great potential e.g. for promotion and advertisement purposes. The easiness of sculpting ice to interesting shapes invokes thoughts of designing in the future, for instance, interactive ice sculptures or otherwise more creative display shapes.

CONCLUSIONS

In this paper we have described our experiment, where an interactive surface utilizing multitouch input was successfully built of ice. Our installation represents a novel approach in experimenting with different materials that can be used for ubiquitous computing and interactive surfaces. While the system is somewhat hard to be generalized as such, the experiment demonstrates that creating holistic designs that match with the environment provoke positive perceptions in the audience.

Natural ice is by nature an inhomogeneous and rather challenging material to be used as a touch surface. However, with careful preparation it is possible to create an interactive surface with adequate performance and the fascinating properties of ice can be used to create impressive visual installations.

The collected feedback also highlighted creating delight through the design. Based on our experiences, we recommend that attention should be paid to the holistic appearance and consistency throughout the overall design of ubiquitous applications, and the possibilities that the use of non-conventional material can offer to emphasize the content or message conveyed through the installation.

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