Dirty Tangible Interfaces — Expressive Control of Computers with True Grit

Figure 1. Users getting their hands dirty on DIRTI.

Figure 2. More or less dirty interaction materials.

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Abstract

Dirty Tangible Interfaces (DIRTI) are a new concept in interface design that forgoes the dogma of repeatability in favor of a richer and more complex experience, constantly evolving, never reversible, and infinitely modifiable. We built a prototype interface realizing the DIRTI principles based on low-cost commodity hardware and kitchenware: A video camera tracks a granular or liquid interaction material placed in a glass dish. The 3D relief estimated from the images, and the dynamic changes applied to it by the user(s), are used to control two applications: For 3D scene authoring, the relief is directly translated into a terrain, allowing fast and intuitive map editing. For expressive audio–graphic music performance, both the relief and real-time changes are interpreted as activation profiles to drive corpus-based concatenative sound synthesis, allowing one or more musicians to mold sonic landscapes and to plow through them in an inherently collaborative, expressive, and dynamic experience.

Author Keywords

Tangible interface; Non-standard interaction; Design-driven; Musical sound synthesis;

ACM Classification Keywords

H.5.2. User Interfaces. H.5.5. Sound and Music Computing

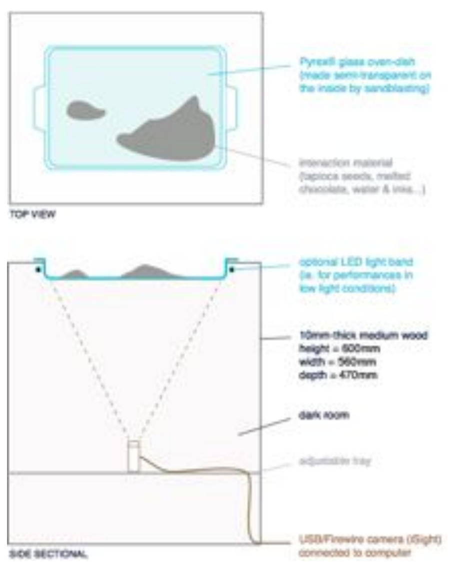

Figure 3. DIRTI hardware prototype schema

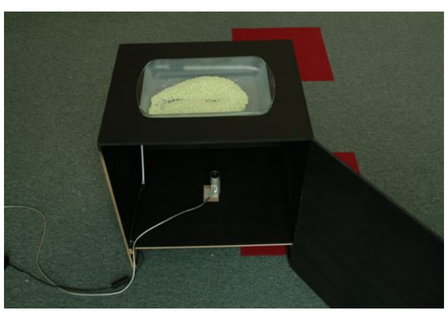

Figure 4. DIRTI prototype, open

Introduction

Should one always manipulate numerous and varied complex data in the same manner as we approach a WIMP (windows, icons, menus, pointer) interface? In this article, we present an interface prototype allowing a user to interact with complex high-dimensional datasets, controlling complexity using a natural gestural palette and with interactions stimulating the senses. In the manner of a hand caressing fur, the apprehension of the complexity is aiming to be corporal, integrating multiple levels of precision/approximation.

We voluntarily distance our concept of *Dirty Tangible Interfaces* (DIRTI) [3] from precise but sterile interfaces that separate the controller from the controlled object, but rather have the interface adapt itself to it, leading to a protean, contextual interface on which the users can get their hands dirty…

Dirty Tangible Interfaces belong to a new generation of complex input devices that take advantage of the finest changes of the environment they are analyzing. This generation of user interfaces (UI) is especially far from the traditional keyboard, mouse, joystick or even graphics tablet that all rely on the boolean and/or continuous sensing of a small number of buttons or potentiometers.

In particular, we call *Dirty Tangible Interface* a tangible user interface that bears the following features:

- The interaction is tangible and embodied using the full surface of the hands, giving rich tactile feedback through the complex physical properties of the interaction material.
- The return to its neutral position is artificial, in the sense that it is only achieved when the user decides so (i.e. via the software that grabs the information from the interface).
- The interface is constantly evolving, and changes that happen, as little as they may be, are not reversible. Only a discretization by the tracking software could reduce the variations, and artificially enable more discrete changes.
- The interface is infinitely customizable by choosing a different interaction material, e.g. grains, liquid, balls.

Our DIRTI prototype interface is based on granular or liquid interaction material placed in a glass dish (see figure 2), the image of which is captured by a commodity USB-camera and translated into a 3D depth image. The prototype interface serves two concrete applications: first, an audio–graphic performance instrument where the interaction with the interface controls musical sound synthesis and generates related, visual behaviors on screen, and, second, a terrain editor for the easy and intuitive creation of virtual worlds. These applications can be seen in the accompanying video and at http://smallab.org/dirti.

Prototype Interface

The prototype interface, see figures 3 and 4, consists of a dark box containing a video camera, a semi-transparent glass dish, surrounded by optional LED lights to perform in darker conditions, and containing the interaction material. Several kinds of interaction materials can be used: dry grains (plastic granulate, tapioca grains, peas, marbles), plastic balls, water with ink(s), ice cream, soft chocolate... depending on the desired expressivity, precision/randomness ratio, and inertia of movement wanted. Movement and density of

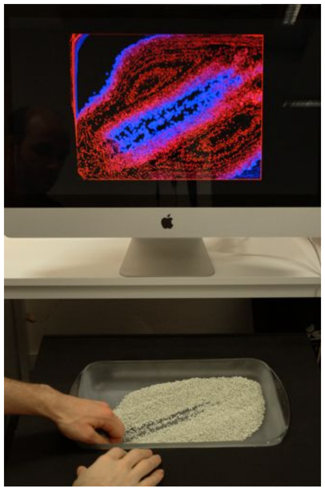

Figure 5. DIRTI detection example

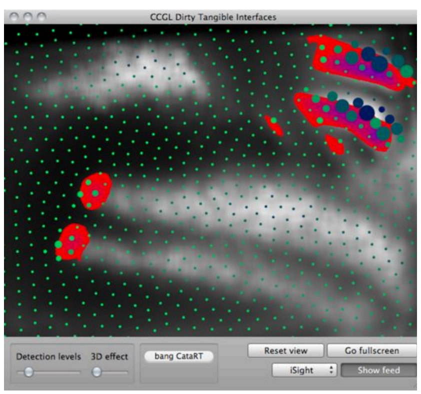

Figure 6. Camera image and audio activation profile visualization

material in the dish are captured from below by a camera placed underneath in order to obtain a gray scale image of the interaction material. This image is then converted by the analysis software into a 3D depth image as described in the following:

Detection and Analysis

The grayscale camera image is the source of detection of various parameters:

- density of interaction material
- motion, quantity of movement applied to it
- colors

Based on the grayscale image, n levels of contours of iso-luminance blobs are estimated in the image, where n is a parameter that determines the depth resolution of the analysis, usually set to 20. These contours are then interpreted as a 3D relief of the material: each subsequent level is assigned a depth coordinate, which is a simple and sufficiently precise way to estimate the density and thus the height of the interaction material (see figure 5). However, for dynamic gestural control, our approach is to detect where there is movement in the material. Therefore, movement detection was implemented that assigns a depth coordinate relative to the speed of movement in each part of the image. More details on the tracking algorithm can be found in [2].

Profiles

Both, the depth of the movement analysis, and the depth derived from the background image, are then interpreted as *profiles*, i.e. 2D fields carrying a parameter value, that are in the musical sound synthesis application applied as *activation profiles* to a sound process [3].

Application to Audio–Graphic Synthesis

Audio

The audio process is based on corpus-based concatenative synthesis (CBCS) [1], where sound is created by selecting segments of a large database of pre-recorded audio (the corpus) by giving a target position in a space where each segment is placed according to its sonic character in terms of audio descriptors, which are characteristics extracted from the source sounds such as pitch, loudness, and brilliance, or higher level meta-data attributed to them.

For Dirty Tangible Interfaces, we project the corpus onto the 2D interaction surface by choosing two descriptors as its axes. Each segment then has a 2D coordinate and can be visualized as a point on the detection visualization (see figure 6).

To play the segment associated to a point, we determine if it lies within a blob, in which case the segment is triggered (if it is not already playing). The depth of the containing blob is mapped to the playback gain, so that fast movements play loud, slow movements play softly.

The background profile can be mapped to a sound transformation parameter. In our experiments, we obtained musically interesting subtle effects by mapping the background to a little amount of transposition randomization. This means that at the beginning, with a thick layer of material, sounds play untransposed, but when digging deeper and exposing the bottom of the dish, chorusing effects can be deliberately produced for specific sound segments.

Figure 7. Screenshot of ***DIRTI Traces*** graphical interpretation

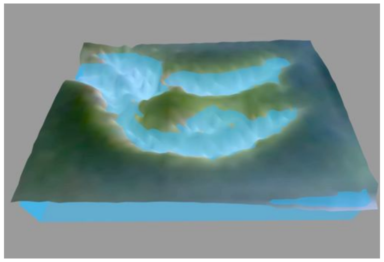

Figure 8. Screenshot of DIRTI Terrain Editor (see **http://vimeo.com/37313858**)

GRAPHICS
For the graphical interpretation of the DIRTI interaction, *Dirti Traces* (see Figure 7), uses the tracked blobs to represent traces of the movements that get eroded and displaced through time, symbolizing the attack, sustain and decay of the sounds produced by the interaction.

Application to Terrain Editing

The second application, *Dirti Terrain Editor* (see figure 8), is useful in the domain of creation of virtual 3D worlds, e.g. for simulation, video games, installation, or cinema.

The terrain editor makes use of the density of the interaction material in the dish to edit a 3D terrain on screen, allowing the user to sculpt mountains, islands, lakes and paths with DIRTI, possibly augmenting the speed of virtual worlds' creation.

Conclusion

The presented prototype implementing the design concept of Dirty Tangible Interfaces is a promising first realization that combines a very sensual and playful approach to interaction with inherent collaborative use, all being based on low cost commodity hardware.

The simple approach of converting luminosity to 3D relief, while less precise than complicated techniques like Laser scanning, is sufficient for meaningful and satisfying interaction. The relief, and the dynamic changes applied to it by the user(s), can be interpreted in many ways to control a wide range of applications. We saw the example of directly translating the relief into 3D terrain for fast maps editing by designers of video games.

In the music performance application, both the relief and real-time changes were interpreted as activation profiles to drive corpus-based, concatenative sound synthesis. As can be seen in the videos at http://www.smallab.org/dirti/, dynamic and expressive musical play is possible, matching the dynamics of the manipulation of the interaction material. Thanks to the mapping of the space of sound characteristics to the interaction space, timbral evolutions can be purposefully controlled.

Acknowledgements

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