1 Introduction

Current user interfaces for computers and mobile devices often separate input and output, are typically static in their physical appearance, and rarely tap humans’ ability to reason about and manipulate physical objects. We propose a new paradigm of interfaces that address these limitations. The paradigm is called Generic and Highly Organic, Shape-changing inTerfaces (GHOSTs).

GHOSTs are display surfaces made of malleable materials that can change into and retain arbitrary shapes so as to display output from the system or afford new actions. At the same time, GHOSTs allow users to deform, touch, or otherwise manipulate the shape of their display surface to provide input to the system. We argue that such interfaces provide many benefits over current user interfaces by leveraging humans’ ability to perceive, express, and communicate through touch and manipulation of physical objects.

In this report we will present our Ghost we designed for this module; Yeti. Yeti is an interactive platform that can be used in multiple not-jet-defined applications.
2 Sensing

For the first exploratory phase of the module we started looking on how people interact, communicate and/or express themselves in tangible objects. We looked at objects within seven different exploratory procedures;

- Lateral motions (Texture)
- Pressure (hardness)
- Static contact (temperature)
- Unsupported holding (weight)
- Enclosure (global shape and volume)
- Contour following (global & exact shape)
- Moving parts

By doing so we explored new fields of interactive possibilities and materiality. The results of the explorations were analyzed and incorporated in an overview of multiple means and goals within these exploratory procedures.

Because our exploration concerned frequency and sliding, the actuation of movement felt most interesting. We chose to explore the movement of a flexible stick with some weight on top that is influenced by changing the length of the moving end of the stick, and by changing the frequency in which it is moved.

The goals that were explored during this step are: Attraction & Rejection, Speed and Frequency. The means we used to achieve these goals are: Sliding, Swinging and Bending. The two parameters that were explored are: the length of the flexible stick and the frequency of moving the flexible stick.
Because the task was to design a ‘surface changing platform’ we chose to make a grid of many flexible pins with some weight on top, which together form a surface. This surface makes it easier to use your whole hand while interacting, instead of just some fingers.

For exploration of the first parameter we need the pins to vary in length. This can be reached by moving them up and down, while only the top of the pins is visible.

To explore the second parameter the ‘starting point’ of the pins needs to be able to move from left to right in variable frequencies. This can be reached by moving the middle part of the pins left to right.

By using two small platforms, one containing a small grid of the pins, and one (with holes) located between the bottom platform and the top of the pins, it was possible to play with the dynamics of action and perception. The bottom platform was moved up and down, and platform with holes was moved from left to right.
To be able to use touch as input, the pins were transformed into a capacitive sensor. For this capacitive sensor the pins needed to be conductive, but for the desired movement they also needed to be flexible. We chose to use steel wire for the pins, and put drops of conductive tin on top for the weight.  

Max MSP was, together with Arduino, used to program the GHOST. In Max MSP different values (the input of the capacitive sensor, and the output to the servo) could be changed, while running the program on the GHOST, to fine-tune the sensitivities of the interactive GHOST.

As one person was interacting with the pins, the other person was controlling the platforms. This way we explored a direct coupling between action and perception as well as increasing, decreasing and inversing the ‘expected’ perception.

Mapping & transformation:  
After exploring the relations between action and perception, and knowing what kind of interaction we wanted to create we started to design and build the prototype. For the kind of interaction we wanted to create, the pins needed to be able to move up and down, and from left to right. To make this possible a construction was designed. This construction consists out of two platforms, both controlled by a servo motor. One platform holds the pins and can be moved up and down, and the other platform can move from left to right to shake the pins. This construction was designed in Solidworks, and the loose parts were laser cut and put together.
4 Final Concept

The final GHOST is called Yeti. Yeti is a shape-changing interface platform. Users are able to interact with Yeti by touching it’s surface. If the user touches this surface for a couple of seconds, the pins on top of the surface start growing towards the user. The ‘expected’ perception was inversed: instead of going away when you touch it, the surface comes towards you. The surprised response from users showed indeed that this ‘inversion’ was unexpected.

After touching the surface shortly for a couple of times, the pins start to shake in the same rhythm as the user is touching them. This is a direct coupling; the GHOST imitates the behavior of the user.

The following electronics were used in Yeti;

- Arduino UNO
- Standard analog servo with plastic gears (2x)
- Tinfoil to create capacitive sensor.
5 Max/MSP Patch

Scaling Sensor value’s of Capacitive sensor to servo value’s, here 72 and 106 are the minimal and maximal servo positions. This servo controls the shaking frequency of the pins.

If the sensor is touched (value is higher than 80), a pulse with a value of 100 is send to the servo every 50ms. Because of this the shaking frequency increases when the interaction frequency drops. (the difference between the sensor value and the value of 100 increases).

Sensor Input (from Arduino)

By clipping the sensor value’s to 300 and 1500, damage by servo’s exceeding their mechanical boundary is prevented.

The signal is smoothed

Graph showing the sensor input value (clipped at 300 and 1500)
Scaling Sensor value’s of Capacitive sensor to servo value’s, here 85 and 165 are the minimal and maximal servo positions. This servo controls the height of the platform.

The signal is smoothed.

Graph showing the raw height signal output.

Graph showing height signal output after additional slide smoother.
#include <Servo.h>
#include <CapacitiveSensor.h>
#include <CapacitiveSensorDue.h>

Servo servohorizontaal;
Servo servoverticaal;

int servohorizontaalPin = 5;
int servoverticaalPin = 6;

CapacitiveSensor cs_7_4 = CapacitiveSensor(7,4);  // 10M resistor
between pins 4 & 2, pin 2 is sensor pin, add a wire and or foil

void setup() {
    Serial.begin(115200);
    servohorizontaal.attach(servohorizontaalPin);
    servoverticaal.attach(servoverticaalPin);
}

int max6Input[] = {0,0};  //now 2

void loop() {
    long sensorValue1 = cs_7_4.capacitiveSensor(30);
    //int sensorValue1 = analogRead(A0);
    //int sensorValue2 = analogRead(A1);

    Serial.println(sensorValue1);
    //Serial.print(" ");
    //Serial.println(sensorValue2);

    if (Serial.available() > 0) {
        for (int i=0; i<2; i++) {  // if 2 inputs i<2
            max6Input[i] = Serial.read();  // put into array
        }

        servohorizontaal.write(max6Input[0]);
        servoverticaal.write(max6Input[1]);
        //delay(200);
        //do something with the values from MAX6:
        //max6Input[0] and max6Input[1]
        delay(50);
    }
}

7 Expert feedback

“Controls are unclear, but interesting”
Many people walked up to the device and started stroking and moving the pins. Most would ask about applications and meaning, but some just continued exploring without asking anything.

Related quotes: “I’m not sure if it wants to be touched/stroked, or wants to be left alone?”

“It Felt like a massage”
Multiple people mentioned it felt like a massage device. The difference in length of the flexible sticks resulted in small pressure point on the hand surface. By changing the shape and position of the hand the pressure on the points could be alternated. This resulted in a massage like feeling.

Related quotes: “It is inviting/interesting to touch”

“Put a cloth on top to get a more organic sensation”
To enhance the organic feel of Yeti, more connections between the pins (by means of a cloth on top) could enhance the feeling of a single platform instead of multiple single elements.

“I thought it would follow my hand movements”
To several experts it was unclear if Yeti responded to touch, or by presence alone (distance, optical, sound, etc.). The link between action/reaction had a slight delay; making the time coupling unclear

Related quotes: “I thought that if I would stroke the pins, it would move from left to right. And it did!”
The movement going left-to-right was more natural than the movement front-to-back.

Related quotes: “If you move left to right, it wants to shake back at you”
“What would the possibilities be if each pin could be controlled individually, instead of a single moving platform.”

“It is trying to imitate my movements”

“I did not get the left right movement”
The added value of moving the pins left-to-right was not understood by all users.

“It is nice that the length and size of each pin is different”

“The Ghost has strong resemblance with the dune project”
The combination of the random swinging movement and the growing element are perhaps linked to the behaviour of grass or reed in the wind. This created a resemblance to the Dune project of D.Roosegaarde.

Related quotes: “Moving up is has strong resemblance to something growing”

“Put a cloth on top to get a more organic sensation”
To enhance the organic feel of Yeti, more connections between the pins (by means of a cloth on top) could enhance the feeling of a single platform instead of multiple single elements.