MetaLife: Interactive Installation Based on Liquid Metal Deformable Interfaces

Qiuyu Lu
Tsinghua University
Beijing 100084, CHINA
lqy17@mails.tsinghua.edu.cn

Yingqing Xu
Tsinghua University
Beijing 100084, CHINA
yqxu@mail.tsinghua.edu.cn

Danqing Shi
Tsinghua University
Beijing 100084, CHINA
shidanqing@mail.tsinghua.edu.cn

Haipeng Mi
Tsinghua University
Beijing 100084, CHINA
mhp@mail.tsinghua.edu.cn

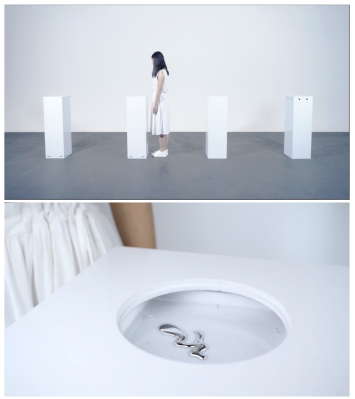

Figure 1: MetaLife

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Abstract
Driving from the novel technology of LIME (LIquid MEtal shape-changing interfaces), MetaLife presents a series of installations for educational, entertainment, or aesthetic purposes. In this paper, we discuss how we translate LIME's interaction paradigms into design vocabulary and how we use such vocabulary to design the installation. As industry and academia become disconnected from each other in the field of tangible user interfaces, MetaLife gives an example of how we can promote the bonds between them.

Author Keywords
Shape change; Liquid metal; Art installation; Product design.

CCS Concepts
•**Human-centered computing** → **Interface design prototyping;** *User interface design;*

Introduction
Shape-changing interfaces have been intensively investigated since the vision of tangible user interface was introduced two decades ago. However, the commercial influence and practical implication of these interfaces are still unclear [1]. The *Samsung Galaxy Fold* mobile phone introduced in 2019 can passively change its screen size and provide dynamic affordances depending on different use

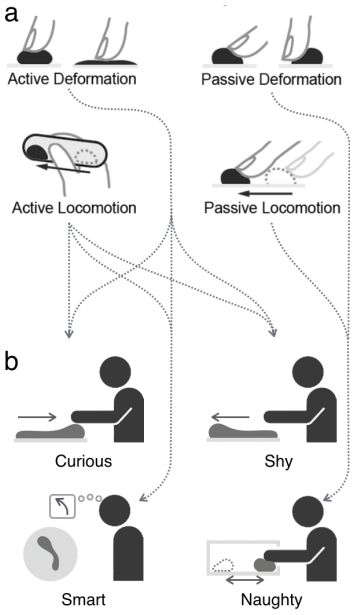

Figure 2: Translating selected interaction paradigms of LIME (a) to the design vocabulary of MetaLife (b).

cases, and is one of the few examples of industry implementation of shape-changing interfaces. In stark contrast to the slow adoption of this technology in industry, the evolution of shape-changing interface in academic is quite radical. While the aforementioned smart phone is still based on mechanical hinges to fold, programmable materials have already been widely utilized by researchers to develop novel shape-changing technology [4]. Recently, even liquid phase programmable materials have been adopted [3, 6, 5]. Although liquid materials have much higher degrees of freedom in shape-change, they require stricter conditions to be contained and controlled compared to solid materials. This makes such liquid-base shape-changing technology is even more difficult to be adopted by the industry.

MetaLife is a project deriving from our prior research work LIME [3]. In LIME, we utilized liquid metal GaIn25's capabilities of reversible shape-changing and controllable locomotion under external electric field stimuli [2, 7] to create a novel shape-changing interface. The interaction potentials of LIME provide us a unique artistic expression and design vocabulary to develop a series of liquid metal installations and products for educational, entertainment, or aesthetic purposes. As the industry and academia are getting divorced from each other, we hope this project can potentially inspire and encourage more researchers, artists, and designers to apply the research results of shape-changing interface to the area of art creation and products design.

From LIME to MetaLife

A GaIn25 droplet can transform from a near spherical shape to a large thin sheet, and vice versa, under the stimulation of an external electric field when in alkaline or acidic electrolyte solution, and the droplet tends to flow towards the cathode while deforming. Utilizing these properties, we designed LIME to afford two categories of interaction: visual effect and dynamic haptic feedback.

During the development of LIME, sometimes we were fascinated by the ever-changing shape of the liquid metal droplet and forgot the existence of the electronic components and chemical solution. Although we knew, rationally, that it was just a small drop of cold abiotic metal, it looked so much like a living amoeba or mollusk that we could not stop thinking of it as a metal-based new life form. Inspired by this, we created MetaLife. We present some interaction paradigms of LIME aesthetically and try to let users associate these interaction styles with some habits and personalities of the living creatures (Figure 2). A liquid metal droplet can actively transform and move to or away from a user, which can make the droplet appear to be timid/shy, daring/curious, or naughty. The droplet can also transform to some meaningful patterns and move to a certain location according to the instruction from the user, which will make it seem like having a certain amount of intelligence. Lastly, a user may feel being close to the "creature" both physically and emotionally by touching and feeling it.

Interacting with MetaLife

The user can play with the liquid metal mollusk for recreation, like playing with a pet. In the education space, we hope MetaLife can arouse interest about the science underlying the technology. Moreover, philosophically, we hope the collision of the lifeless metal appearance and the lifelike behavior may prompt users to rethink about what life actually is. At last, functionally, one can simply use MetaLife as the home decoration.[1]

Being Shy (Figure 3.a) - The mollusk will swim out from the nest and wander in the "seawater" (1mol/L NaOH Solution) when no person is around. However, the mollusk will get scared and return to its nest quickly when the user gets too close ($\leq$ 30 cm).

[1] The full video of users interacting with MetaLife.

Figure 3: The liquid metal mollusks with different personalities: being shy (a), curious (b), smart (c), and naughty (d).

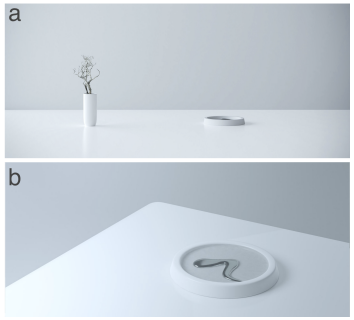

Figure 4: The rendering images of a small size MetaLife installation as the home decoration (a) and displaying time like a clock (b).

Being Curious (Figure 3.b) - The mollusk can also be very outgoing. If there is nobody around, it will stay in the nest located in the middle of the installation. When a user approaches ($\leq$ 30 cm), the mollusk will swim towards him/her. If there is more than one user around, the mollusk will swim to the closest one.
Being Smart (Figure 3.c) - The mollusk can "understand" instructions from the user. There are small pieces of "food" (aluminum foil) in the tank. A user can navigate the mollusk to the food by inputting their instructions via the buttons. Once the mollusk finds the food, it will "swallow" the food and begin to spin and swim happily until the food is completely digested [8].
Being Naughty (Figure 3.d) – There are some naughty mollusks hiding in their nest and continuously moving. A user can put his/her finger into the holes around the nest to find and touch the mollusks, which is kind of like playing with naughty pets. When the user finally touch them, they can provide a cold, elastic haptic feedback that feels very similar to a real mollusk.
Decoration/Function (Figure 4) - Such installation can be used for house decorating, such as dynamic paintings or clocks. For example, the curious mollusk can deform and swim to two different direction simultaneously, acting like the hour hand and the minute hand to indicate time.

Implementation of MetaLife

The system overview is as Figure 5. The cost of each installation is around 80 USD.
Input - Ultrasonic distance sensors are used to detect the approaching of users' feet or fingers. Sensors for the 'shy' and 'curious' installations are at the bottom, while sensors for 'naughty' are placed inside the "nest". As to the installation 'clever', the inputs are four buttons representing four directions.
Control – The Arduino Mega 2560 boards are used to process the input signals and control a relay control board, or a motor driver board to switch on/off the electrodes or mo-

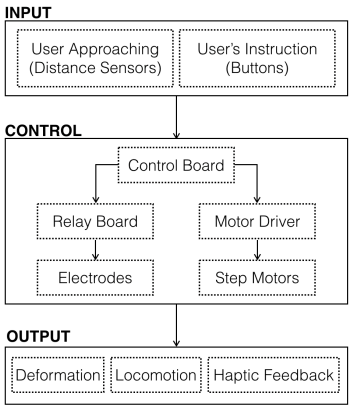

Figure 5: The system overview of MetaLife

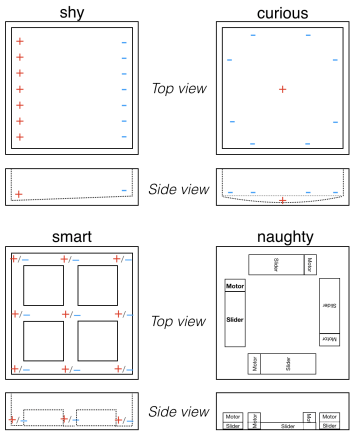

Figure 6: The design of the containers and the layouts of the electrodes

tors. Importantly, to make sure users can touch the liquid metal safely, liquid metal droplets in installation 'naughty' are sealed in thin plastic chambers and their movements are driven by step motors rather than electrochemical reactions.

Output – The Liquid metal mollusk will perform transformation/locomotion or provide haptic feedback to the users. The containers and the layouts of electrodes are specially designed corresponding to different behaviors of the mollusk (Figure 6).

Conclusion

MetaLife is an attempt to apply our research results of shape-changing interfaces towards artistic creation and product design. We found that a shape-changing interface is very suitable to mimic living creatures, offering natural interaction experiences similar to people's interactions with pets in daily life. When this work was present in Ars Electronica (an art exhibition), many artists/designers showed their interests in the research work about shape-changing interface and their will of adopting such novel technology as a design language. While in the community of CHI, we hope this attempt can encourage researchers to think about how to possibly bridge the gap between industry and academia.

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