# Digital Fabrication and Manipulation Method for Underwater Display and Entertainment

Amy Koike
University of Tsukuba
amy23kik@gmail.com

Satoshi Hashizume
University of Tsukuba
pota1401@hotmail.co.jp

Kazuki Takazawa
University of Tsukuba
1220kazu1412@gmail.com

Mose Sakashita
University of Tsukuba
sakasita86@gmail.com

Daitetsu Sato
University of Tsukuba
sato.daitetsu.sm@alumni.tsukuba.ac.jp

Keisuke Kawahara
University of Tsukuba
kawahara@ai.iit.tsukuba.ac.jp

Yoichi Ochiai
University of Tsukuba
wizard@slis.tsukuba.ac.jp
University of Tsukuba

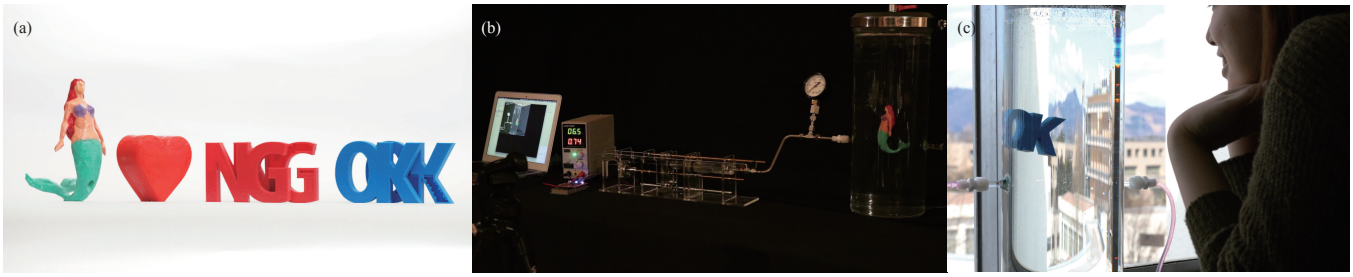


**Figure 1: (a) Cartesian Divers designed using our method. (b) A mermaid is floating in the middle of water tank by PID control. (c) A girl is looking at the message.**

## CCS CONCEPTS

• **Computing methodologies** →*Shape modeling;*

## KEYWORDS

Digital Fabrication, underwater entertainment, 3D print

**ACM Reference format:**
Amy Koike, Satoshi Hashizume, Kazuki Takazawa, Mose Sakashita, Daitetsu Sato, Keisuke Kawahara, and Yoichi Ochiai. 2017. Digital Fabrication and Manipulation Method for Underwater Display and Entertainment. In *Proceedings of SIGGRAPH '17 Posters, Los Angeles, CA, USA, July 30 - August 03, 2017,* 2 pages.
DOI: 10.1145/3102163.3102226

## 1 INTRODUCTION

Underwater expression is attractive. It seems like underwater objects are floating like anti-gravity scape by buoyancy, and it is also impressive that bubbles rise while refracting the light. In this work, we aim to combine digital fabrication with interactive technology and expand underwater expression. To achieve this, we focused on a classic science experiment called the Cartesian Diver. Because of growing interest in the materialization of computer graphics, digital fabrication technologies have recently emerged as one of the most important application fields in real-world-oriented computer graphics. In particular, research on digital fabrication that gives dynamics properties is common. Spin-it [Bächer et al. 2014] presents design method for spinning objects by optimizing rotational dynamics properties. Some studies use non-contact manipulation. For example, ZeroN [Lee et al. 2011] controls the magnetic field to manipulate the object and uses it as a floating screen and input user interface(UI). Our work connects digital fabrication and non-contact manipulation that uses the space transmission power (water pressure) around the object (the diver). [Koike et al. 2016] proposes a design and manipulation method for the diver. In this work, we updated the method and investigate stability of PID control. Furthermore, we propose some applications.

## 2 IMPLEMENTATION

Our implementation has two phases; fabrication and manipulation.

*SIGGRAPH '17 Posters, Los Angeles, CA, USA*

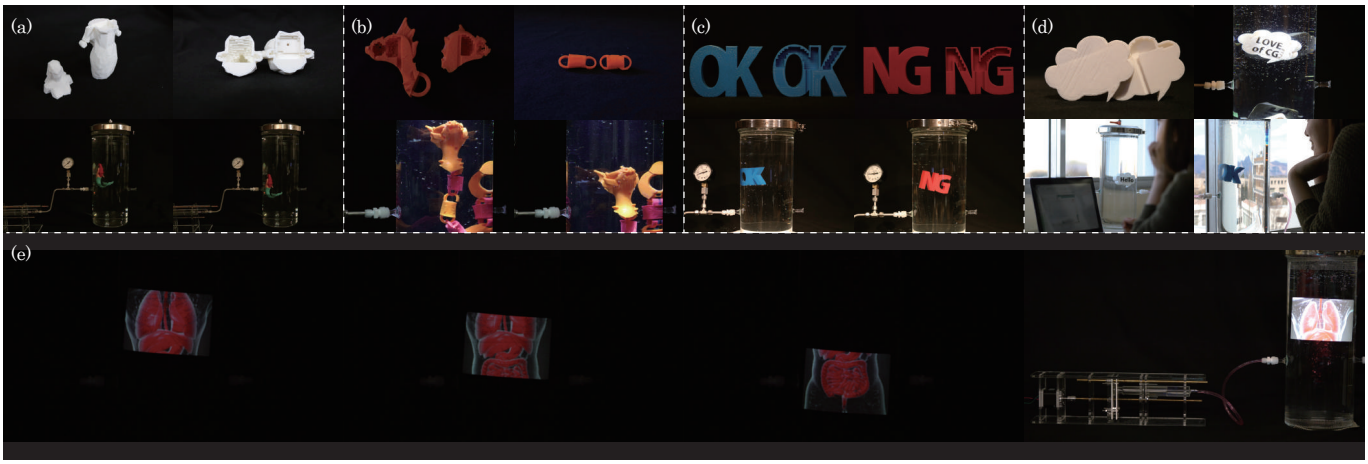


**Figure 2: Various applications of this work.**

In the fabrication phase, we created an algorithm to calculate the appropriate amount and position of the cavity inside 3D model. As the conditions for the 3D model to function as the diver,

- it has to float when you first put it into a water tank.
- it is necessary to have a hole which water enters the object when water pressure is applied to the water tank.
- rotation moments should not be occurred so that the object floats up and down with the correct orientation.

In the manipulation phase, we developed an equipment to manipulate the diver. It has a glass tank connected with motor-worked syringe pomp. (Figure 1(b)) We can applied water pressure to water tank by moving the syringe pomp. And it also has a camera connected PC to feedback the position of the diver in water tank for PID control.

## 3 RESULT

We designed various shaped 3D models showed in Figure 1(a). Behavior of two divers under the PID control is showed in Figure 3. Although it seems that there is some shake due to camera tracking delay, the diver keeps floating in the middle of water (target line) tank without hitting the upper part or the lower part of the tank.

## 4 APPLICATION

### 4.1 Various shaped 3D models

We designed a mermaid (Figure 2(a)) and a dragon (Figure 2(b)). The body of the dragon consists of some parts, so it shows funny movements when water pressure is applied.

### 4.2 Messaging

We designed the diver that has information presentation function. We fabricated the diver in the form of alphabet

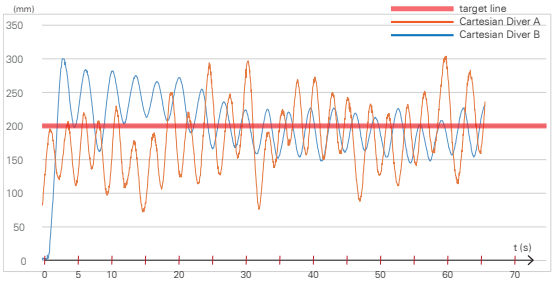


**Figure 3: This graph shows behavior of two Cartesian Divers while PID control that manipulates them to stabilize at the target line. Red line is a target position, and A (Orange line) is smaller and lighter than B (Blue). B is moving steadily than A.**

(Figure 1(c) and Figure 2(c)) and the form of a speech balloon (Figure 2(d)).

### 4.3 Moving screen

We propose a diver which works as a screen in the water tank. Figure 2(e) expresses scanning the body tissue.

## REFERENCES

Moritz Bächer, Emily Whiting, Bernd Bickel, and Olga Sorkine-Hornung. 2014. Spin-it: Optimizing Moment of Inertia for Spinnable Objects. *ACM Trans. Graph.* 33, 4, Article 96 (July 2014), 10 pages. DOI:http://dx.doi.org/10.1145/2601097.2601157

Amy Koike, Satoshi Hashizume, Mose Sakashita, Yuki Kimura, Daitetsu Sato, Keita Kanai, and Yoichi Ochiai. 2016. Syringe-worked Mermaid: Computational Fabrication and Stabilization Method for Cartesian Diver. In *SIGGRAPH ASIA 2016 Posters (SA '16)*. ACM, New York, NY, USA, Article 35, 2 pages. DOI: http://dx.doi.org/10.1145/3005274.3005316

Jinha Lee, Rehmi Post, and Hiroshi Ishii. 2011. ZeroN: Mid-air Tangible Interaction Enabled by Computer Controlled Magnetic Levitation. In *Proceedings of the 24th Annual ACM Symposium on User Interface Software and Technology (UIST '11)*. ACM, New York, NY, USA, 327–336. DOI:http://dx.doi.org/10.1145/2047196.2047239