Open Soft Machines: Challenges for sharing recipes of soft robots

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INTRODUCTION

We present the progress of our effort of sharing the knowledge to make soft robots. Many innovative soft robots and soft materials have been developed in academia, and such new technologies gradually penetrate other fields [1]. However, research papers are not the most suitable medium to share knowledge on how to make such soft robots because they involve many delicate fabrication processes that require diverse and detailed instructions. We propose an online platform introducing video tutorials to build soft robots made of soft materials (www.opensoftmachines.com). We describe its design guidelines and discuss its possibilities and future work. The knowledge shared over this online platform is expected to be used in schools and maker spaces.

BACKGROUND

A. OPEN PLATFORMS AND MAKER SPACES

In recent years, an increasing number of maker spaces are opening at universities and in public spaces. Not only hardware tools, but also design software and open sharing platforms, play an important role in helping makers create things easily and collaboratively in such an environment. For example, students can design and collaborate with Autodesk's Fusion 360 free of charge, actively share what they have designed via open platforms such as Thingiverse [2], and visit maker spaces such as FabLab to fabricate their designs. As this implies, for the democratization of making things, synergism between online platforms and maker spaces is important. Furthermore, to make things more diversified from now on, it is important to expand the number of materials handled in these platforms. Recently, the Bio Hack Academy [3] appeared as an approach to handle new materials with tutorials and an open platform to share their data based on maker spaces. In the case of soft materials and soft robots, because of the lack of shared knowledge, there are very few maker spaces or universities that offer the use of these materials.

B. SOFT MATERIALS AND ROBOTICS

Soft robots form a relatively new domain of research in robotics. The word “soft” refers to the physical property of “softness.” A soft robot can blend itself naturally into the everyday environment and facilitate human interaction because of its soft nature. In the field of human–computer interaction, researchers also analyze soft robot trends and have many expectations for applications [4, 5]. However, discussion on soft robots is still rare among many online and offline educational platforms, and it is a field that needs discussion for systematization.

Typical online websites include the Soft Robotics Toolkit [6, 7] and Materiability [8]. The Soft Robotics Toolkit is a cooperative effort by multiple laboratories established to handle detailed parameters with professional explanations and digitized design data. Materiability is focused on students who design things using soft materials. Explanatory descriptions featuring photographs in these web sites are the most fundamental methods for explaining the process of creating soft robots, but it is difficult to understand the details of each process by this format alone. Through videos, it becomes possible to teach the fine nuances of each fabrication process. In this research, we focus on a method to facilitate the building process understanding and share recipes that convey all processes through a website in the format of a short movie.

METHODOLOGY

The target audience of this research is primarily researchers of both robotics and other disciplines. However, the target users of our platform include a wide range of individuals such as middle and high school students. The goal of this paper is to describe the building of an open-sharing platform for soft robot recipes to increase reproducibility. Furthermore, by showing the process from material to robot and providing examples of combinations of recipes, we hope to expand its applications.

A. A MOVIE FORMAT RECIPE

At the landing page of this website, users can easily find the recently uploaded recipes from the YouTube channel list (Fig. 1). Users can see the detailed recipe by clicking the thumbnail of each recipe. Each recipe page is basically composed of a short video, a list of materials, an explanatory description with photos, and additional references. The earliest maker space is the household kitchen. Many online cooking recipe sites now include rich contents as short movie clips. Among them, Top-View movies are preferred as a way to explain the procedure from a subjective point of view. Therefore, we also built a shooting booth so that Top-View shots can be captured easily. Scenes that show detailed work and tips are shot with Side-View and Close-Ups. The length of the video was compiled finely to last approximately 2 min so as to cover the entire flow.

B. A RECIPE MAP

A robot consists of many parts, sensors, and actuators. To show the relationship between the combinations of parts, we classified the contents into five categories: Materials,

Actuators, Sensors, Tips, and Robots. Even if the appearance and the role of the parts are similar, those with different working principles and different fabrication processes were classified as different recipes ((A) and (B), Fig. 2). We also prepared a recipe map for understanding the relationships between those recipes based on categories (Fig. 2). Lines represent the components that form specific systems. For example, to make a tripod robot (C) using artificial muscles, users may look at the recipe of an artificial muscle (A) first. By visualizing the connection between components, users can learn the fabrication process step by step. When the number of recipes increases, further classifications related to the movement of the actuator or the function of the robot could be considered. This could help individuals plan the learning process by themselves by imagining the function and movement related to an application.

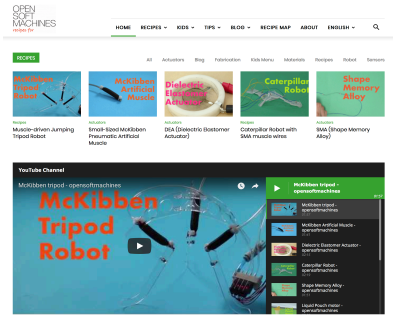

Fig. 1 View of Open Soft Machines

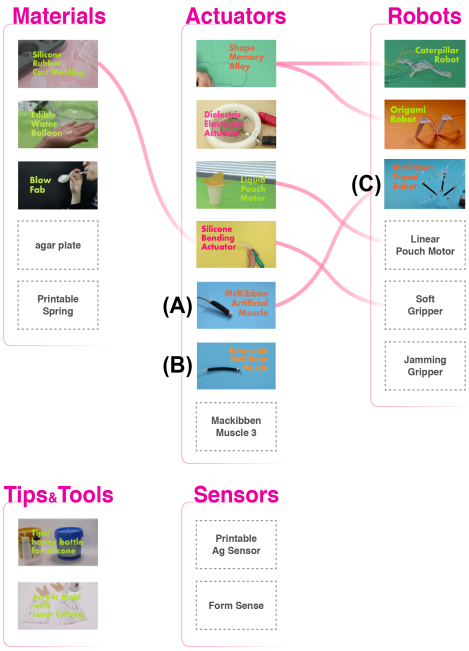

Fig. 2 Categories and structure of recipes

C. MATERIALS

Amazon's "1-Click ordering" enhances the purchasing experience. To let users quickly purchase the material so as not to interfere with the creative process, we provided a website link where users can purchase materials.

In case the handling of the material requires special care, a notice is posted. A guide for mixing ratios of multiple materials is also stated so that these can be combined by the users.

D. ADDITIONAL RESEARCH INFORMATION

To provide accurate information, we faithfully researched and reproduced the process based on academic references. In some cases, we invited experts to ask them to introduce their own research and confirm details of the recipe. In the case of work by an expert, we also post information on that expert, related research literature, recommended documents, and the expert's website. As a result, expert knowledge is made available to those who want to learn more from the recipe.

FINDINGS AND DISCUSSION

We prepared 11 recipes and released a beta version on April 24, 2018. When we announced Open Soft Machines on Facebook on June 8, the number of visitors increased from 119 to 557, compared to the previous month. The returning visitor rate in June was 17% (i.e., almost one in five visited again).

For qualitative evaluation, we received feedback from researchers on soft robots and experts who helped create the recipes. Even researchers in the same field saw concrete methods to manufacture soft materials and robots for the first time. Consequently, it was a very impressive experience for the researchers, leading them to research the possibilities of new applications and interactions based on soft materials. In addition, experts who helped in making recipes used recipes actively as a source to introduce their research to the public in an easy-to-understand manner at subsequent conference presentations and invited lectures. For researchers involved in soft robots, Open Soft Machines was highly appreciated as a platform for understanding and developing this field.

Furthermore, at the first soft robot conference held by IEEE (RoboSoft 2018), we invited and received feedback from the core members of the Soft Robotics Toolkit, Materiability, and the Bio Hack Academy. From the discussion, we defined four issues that must be addressed. First, to continuously produce recipes, it is necessary to create a simple format that facilitates the development of recipes for the organizer. Second, designing website functions to receive feedback from users (e.g., writing comments, participating in discussions, or proposing their own new designs) is necessary. The third issue is to effectively use social media for connecting individuals with interests in soft robots. Finally, to continue to foster a sense of community through our open platform, it is necessary to properly evaluate the effect.

FUTURE WORKS

In this paper, we implemented and evaluated an online platform for sharing soft robot recipes. We are planning to practice method of manufacturing soft robots presented on this online platform at further workshops and through university lessons for evaluating the reproducibility and the applicability. Afterward, we also expect this knowledge of soft robots to gradually penetrate maker spaces.

ACKNOWLEDGMENTS

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