

# Development of Origami 3D Printer

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## Abstract

Now Additive 3D printer(hereafter called Add-3D) has become very popular. But it has some shortage such as it is very difficult for large scale model, necessary much time for manufacturing and expensive for small and medium-sized enterprises. It is effective only to forging and casting except for heading among the three major process. So we have developed Origami-3D printer named “ Ori-3D”[1]-[2] where the object is constructed by human hands or by Origami robot from 2D pattern which are generated by reverse engineering technique[3] from 3D data based on photo and CAD etc.. Ori3D realizes three-dimensional origami very effectively and precisely for very complicated 3D structure. In Ori3D at first, the surface is segmented to several developable surfaces as large as possible using segmentation technique which is used in reverse engineering system. After that, each developable surface is developed 2D pattern with mountain & valley lines and glue parts. In Fig.1, the surface is presented with very precise STL data by using 26 photos of stuffed panda. And after that the surface is simplified with keeping the characteristics and is compared with Add-3D for the same largeness as the one which can be the largest Add-3D can develop because the one formed by Add-3D is limited because of its monolithic molding.

Fig.2(VI) is 2D developed view of Reversed Spiral Cylindrical Origami Structure[4](hereinafter called RSC) by Dr. Nojima. General speaking, there are very few who can draw such 2D developed view. We can construct RSC such as Fig.2 (I) based on Fig.2 (VI). And Ori-3D can give plural 2D developed views such as Fig.2 (V). Strongly speaking, though it is different between Fig.2 (V),(VI),3D structure constructed is the same based on between Fig.2 (V), (VI) . Fig.2 (II) is made of aluminum based on Fig.2 (V). In the case of a piece of paper, it is same the easiness for constructing Fig.2 (I) based on between Fig.2 (v) and (VI) but for aluminum, it is much easier based on (V) than based on (VI). Fig.2 (IV) is made by hydro forming[5]which has 1.4 times more absorbed energy than present absorbed crash energy structure of vehicle body with same weight based on suitable combination among parameters such as  $\alpha$ ,  $\beta$  in Fig.2 (VI). Although the RSC is not yet adopted for real body really because of its expensiveness with hydro forming, Fig.2 (II) of aluminum is rather easily formed based on Fig.2 (V) than based on Fig.2 (VI).

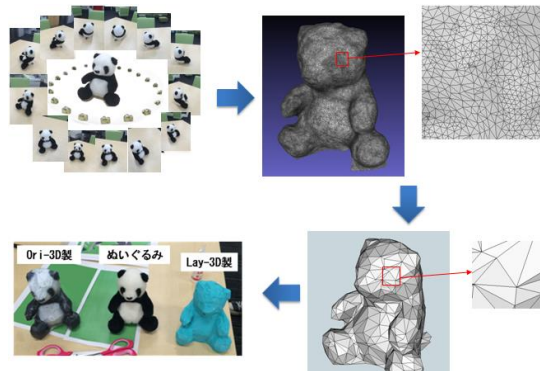


Fig.1 Procedure for real model by Ori3D and comparison among Ori-3D, Add-3D and real physical model



Fig.2 2 types of 2D pattern for RSC, 3D RSC by Ori3D & Add-3D and by hydroforming

From considering Fig.2 (II) of Aluminum is rather easily formed based on Fig.2 (V), this means that it is cheaply formed even with metal if selected suitable 2D developed views drawn by Ori-3D. Many Origami structures have been given up to be realized because of its high cost for forming and so the instruction how the cost for forming becomes the cheapest by modifying many 2D figures by the ways of segmentation of 3D structure. If Origami robot can fold the panda in Fig.1 for example , it is all automatically from getting 3D data to constructing 3D structure. So we call this system Ori-3D. As far as Ori3D, Origami robot is the key technology for it. Origami robot for folding paper has been supposed to be rather difficult but the author group is progressing it. The reason for success can be guessed from Figs 3 and 4. In Fig.3,we can see 3 patterns among which Origami robot with only bending ability can treat only the third pattern because the tree structure of the third one has not closed circle. Fig.4 will be the foldable Tokyo Olympic hat. The original pattern was developed by Dr. Nojima. It is very difficult because for example when Origami robot folds the glue parts, it also folds the structure on its extension except on mountain or valley lines. On Fig.4(b),the place of glue parts are changed to be open tree structure gained. Only after such modification, Origami robot can fold this hat. Here we discuss how we can get generally the open tree structure for even such a complicated structure as the panda in Fig.1.

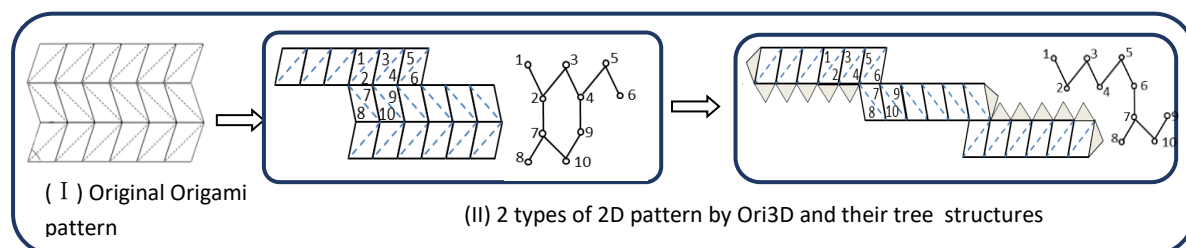


Fig.3 Original Origami RSC pattern ,2 types of pattern for RSC by Ori3D and their tree structures

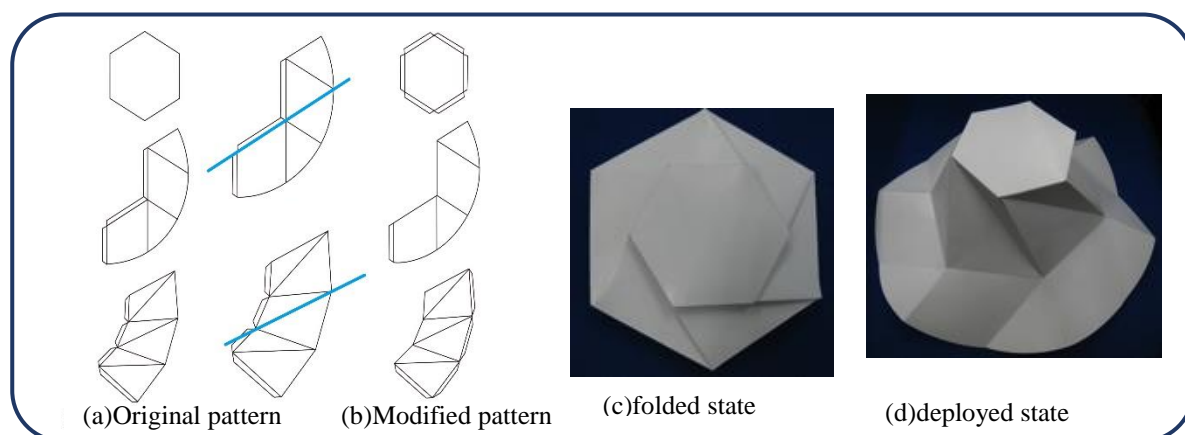


Fig.4 Original 2D pattern and modified one of Olympic hat

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