Supplementary Material
Disjoint Convex Shell and its Applications in Mesh Unfolding

Abstract

This documents contains supplementary materials for Submission 46 titled "Disjoint Convex Shell and its Applications in Mesh Unfolding."

Table 1: Running Time (seconds)

Model	Triangles	**LSF**	**SVM**	**Exact**
Bowser	999	4.153	18.708	16.391
Brain	1209	2.553	8.811	9.018
Bulbasaur	4971	5.440	10.673	11.705
Bull	105988	17.584	28.386	27.127
Chicken	5000	5.070	12.087	12.479
Cow	5804	7.575	14.257	14.888
Crocodile	5250	6.065	9.922	9.770
Dancing Children	3000	8.898	10.665	11.451
Donkey Kong	900	2.428	18.224	19.557
Frog	53006	8.841	12.091	13.734
Haechi	5001	4.878	12.034	11.940
Hover bike	9331	4.290	45.018	52.604
Mother	996	4.006	8.002	8.306
Pikachu	4368	5.504	7.866	8.017
Rabbit	61026	15.658	23.398	23.221
Rocket	254541	55.131	61.148	59.383
Squirtle	1718	3.401	6.051	6.307
Ultraman	4999	8.140	10.300	11.012
Vulpix	1934	4.932	6.409	7.125
Yoshi	677	3.609	11.730	12.583
union	1525	0.039	0.039	0.038

1. Running Time and Volume loss.

Table 1 presents the running time in seconds in building DC-shells along with the triangle size of each model used.

The quality of DC-shell is measured by volume loss from trimming the input convex shapes. That is to say, a DC-shell has higher quality if it removes less material from input to provide disjointness. More specifically, volume loss is defined as

$$\frac{\text{vol}_{orig} - \text{vol}_{shell}}{\text{vol}_{orig}}, \qquad (1)$$

where vol_{orig} is the volume of the union of the original convex shapes and vol_{shell} is the sum of the volume of all disjoint convex shells. Fig. **??** reports the volume loss in percentage of all DC-shells generated from least-squares fit, SVM, and the exact methods.

Table 2: Quality of DC-shells produced using least squares fit (LSF), SVM and exact methods is measured by volume loss defined in Eq. 1. The penalty parameter C is 100 for all examples. The method with the largest volume loss for each model is shown in bold.

	Orignal volume	**LSF**	**SVM**	**Exact**
Bowser	1112400	0.37%	**0.59%**	0.29%
Brain	508.462	**2.69%**	1.32%	1.17%
Bulbasaur	883179	0.15%	**0.18%**	0.14%
Bull	1.91992	**24.67%**	10.76%	2.12%
Chicken	142277	0.10%	**0.18%**	0.10%
Cow	110099	**11.93%**	1.32%	1.03%
Crocodile	27460.2	**33.09%**	4.46%	4.40%
Dancing Children	4739.83	**3.00%**	1.62%	0.86%
Donkey Kong	332858	**22.48%**	1.90%	1.73%
Frog	93009.3	**1.83%**	0.24%	0.24%
Haechi	291371	**0.73%**	0.64%	0.62%
Hover bike	159621	6.70%	**10.62%**	5.79%
Mother	295009	**0.74%**	0.49%	0.31%
Pikachu	80684.7	**0.181%**	0.102%	0.096%
Rabbit	366139	**1.36%**	0.84%	0.67%
Rocket	3684920	0.84%	**4.2%**	0.40%
Squirtle	98.6569	0.25%	**0.45%**	0.22%
Ultraman	297887	**11.24%**	1.13%	1.07%
Vulpix	247.295	0.64%	**0.65%**	0.42%
Yoshi	576266	0.56%	**0.69%**	0.47%

2. Fabrication

We export each net to a SVG (Scalable Vector Graphics) file in which the boundary of the net is represented as a polygon and all the crease lines are represented as single paths. The SVG file is inputted to *Cricut Explore*® machine which will cut the polygon (boundary of the net) out of the paper (12in × 12in) and score all the crease lines which makes folding much easier. We then manually fold each component and stitch all the cutting edges using tapes.

Figure 1: Physical models built from DC shells. Addition two fabricated models are Chicken and Charmander models. The construction time of each paper model is around 2 hours by an adult.

3. Results from Mesh Regularization

Figures 2 and 3 include a complete study of our remesh method.

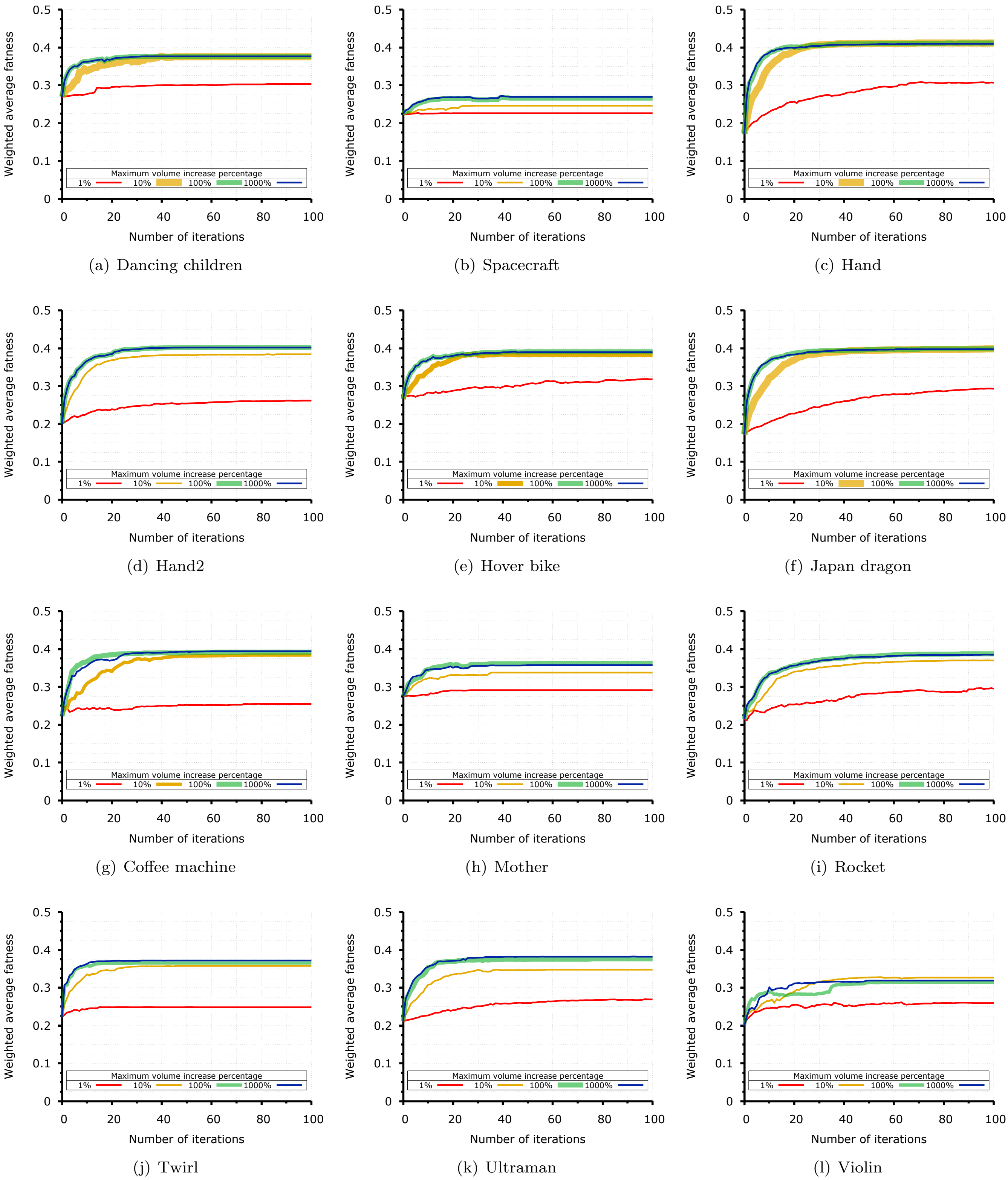
4. Results from Case Study

Here we show a complete set of images of DC-shells created by the proposed methods. Images in Figures 4 and 5 from left to right show: Original, LSF, SVM, Exact DC-Shells.

5. User Study

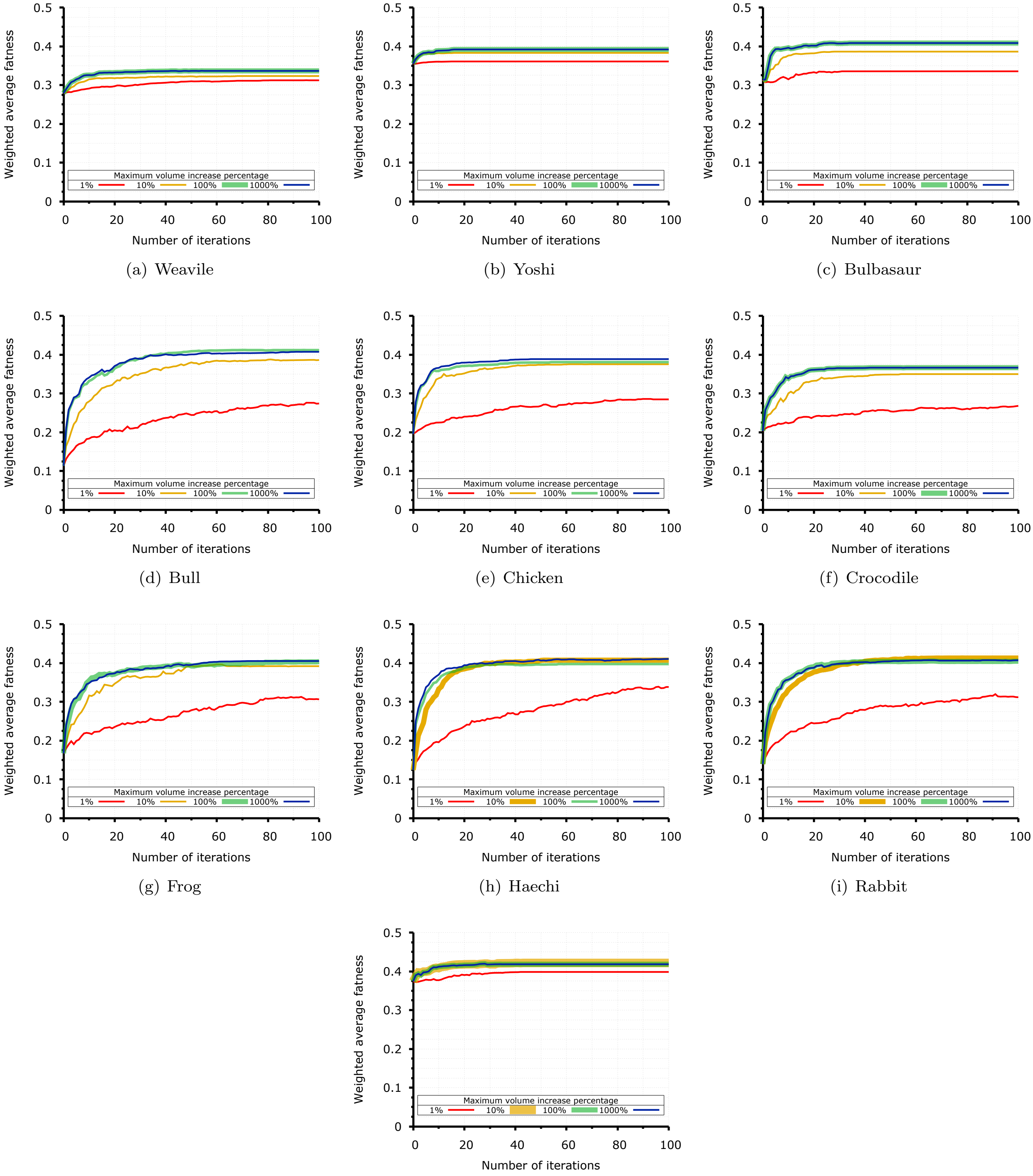
We conducted a user study with 102 young children at an elementary school whose ages are 9 and 12 years old. Depending on their lessons, we selected eight models including Bulbasaur, chicken, bull, crocodile, Haechi, rabbit, frog, and Squirtle. The students then decorated their models to be used in a puppet show in class after finishing models. Students are divided into groups of three or four. They manually fold each component and stitch all the cutting edges using tapes.

Figures 6 to 9 show photos of these students folding paper craft in class.



(a) Dancing children (b) Spacecraft (c) Hand (d) Hand2 (e) Hover bike (f) Japan dragon (g) Coffee machine (h) Mother (i) Rocket (j) Twirl (k) Ultraman (l) Violin

Figure 2: Weighted average fatness with respect to number of iterations at four different percentages of maximum volume increase: 1% (red), 10% (yellow), 100% (green), and 1000% (blue).



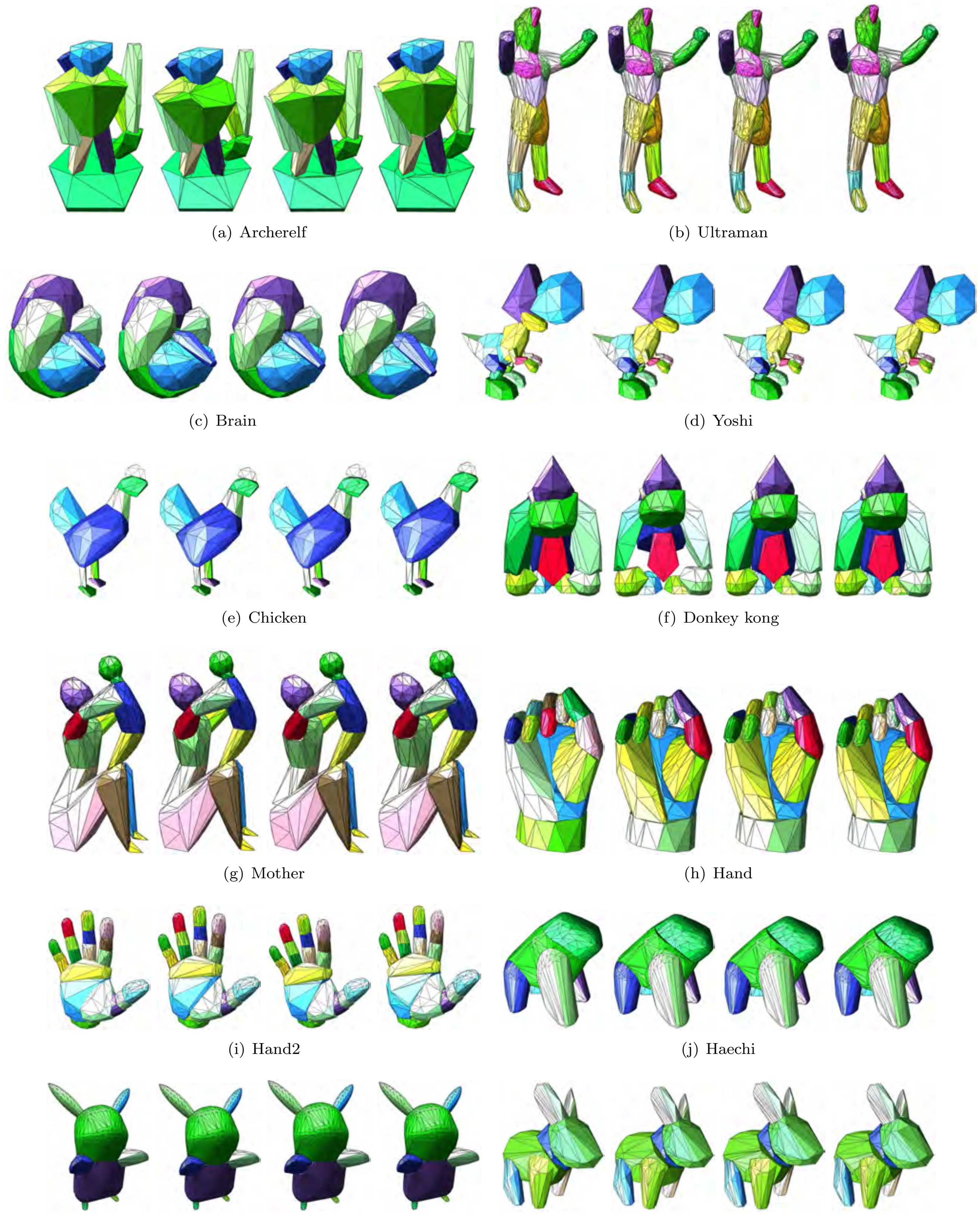
(a) Weavile (b) Yoshi (c) Bulbasaur

(d) Bull (e) Chicken (f) Crocodile

(g) Frog (h) Haechi (i) Rabbit

(j) Squirtle

Figure 3: Weighted average fatness with respect to number of iterations at four different percentages of maximum volume increase: 1% (red), 10% (yellow), 100% (green), and 1000% (blue).



(a) Archerelf (b) Ultraman

(c) Brain (d) Yoshi

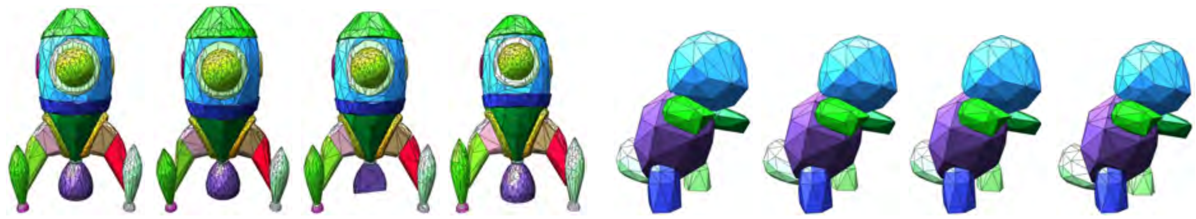
(e) Chicken (f) Donkey kong

(g) Mother (h) Hand

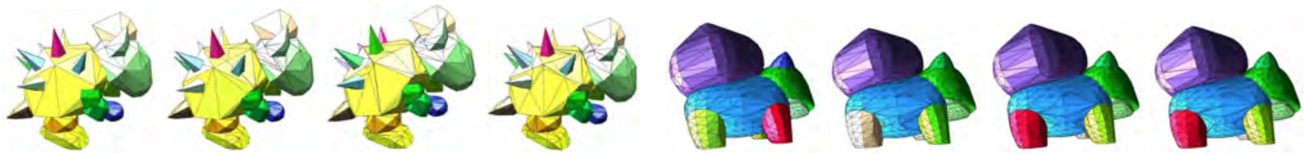
(i) Hand2 (j) Haechi

(k) Pikachu (l) Rabbit

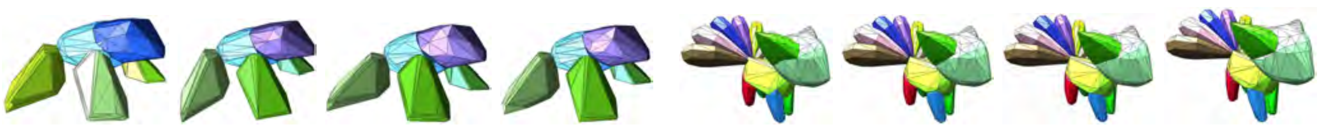
Figure 4: From left to right: Original composite shapes, DC-shells created by LSF, SVM, Exact methods



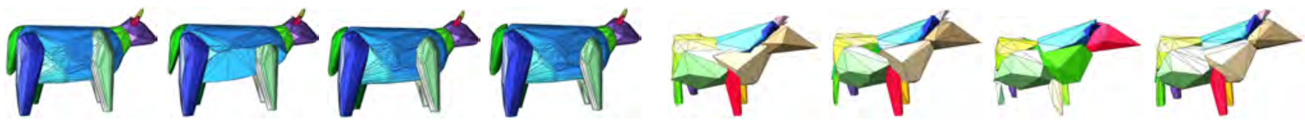
(a) Rocket (b) Squirtle



(c) Bowser (d) Bulbasaur



(e) Frog (f) Vulpix



(g) Bull (h) Cow

(i) Hover bike

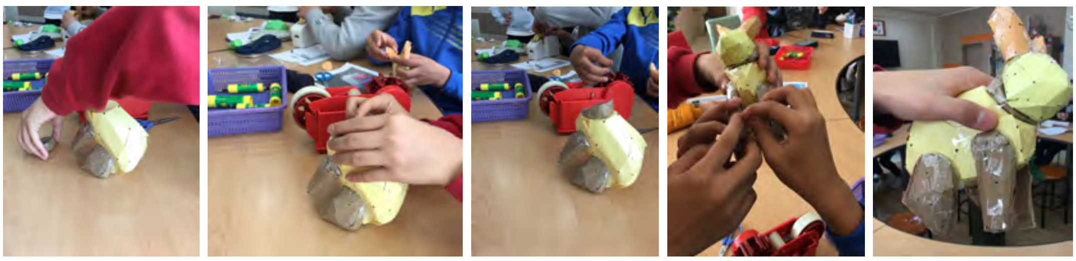
(j) Dancing children

(k) Crocodile

Figure 5: From left to right: Original composite shapes, DC-shells created by LSF, SVM, Exact methods

Figure 6: Groups of 3 to 4 students working together.

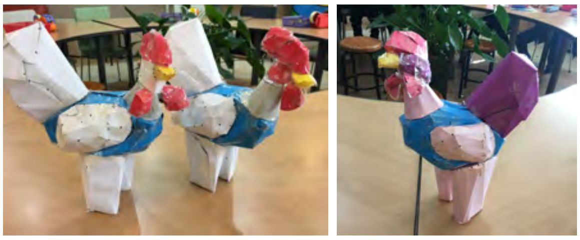
(a) Chicken



(b) Rabbit

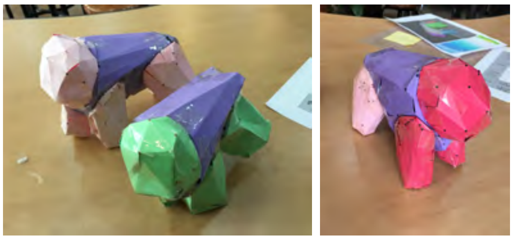
Figure 7: Fabrication Sequence

(a) Bulbasaur

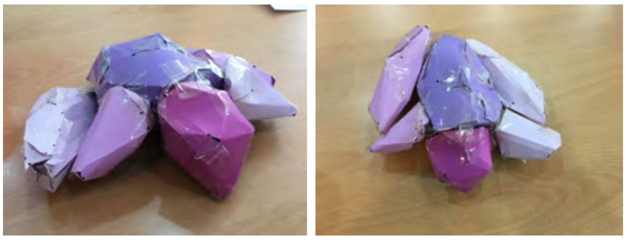


(b) Chicken

(c) Crocodile



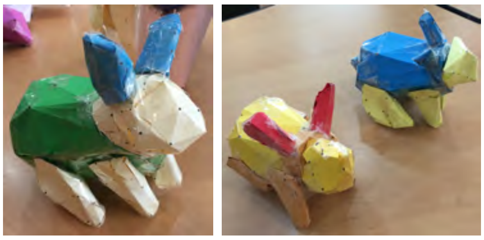
(d) Haechi



(e) Frog

(f) Squirtle

(g) Bull

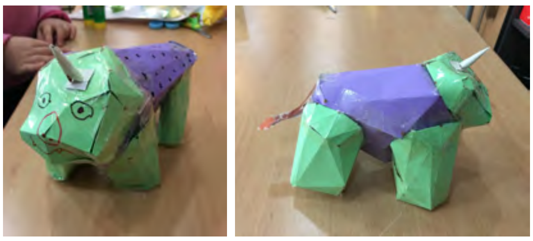


(h) Rabbit

Figure 8: Paper craft models created by 9 and 12 year old elementary-school students.

(a) Bulbasaur

(b) Rabbit



(c) Haechi

Figure 9: Decorated paper craft models by students.