Supplementary: As-Locally-Uniform-As-Possible Reshaping of Vector Clip-Art

CHRYSTIANO ARAÚJO, University of British Columbia, Canada
NICHOLAS VINING, University of British Columbia, Canada and NVIDIA, Canada
ENRIQUE ROSALES, University of British Columbia, Canada
GIORGIO GORI, Adobe Research, USA
ALLA SHEFFER, University of British Columbia, Canada

A STUDY I: RESHAPING INTENT

Our ALUP reshaping algorithm is guided by observations from a small-scale perceptual study, which we conducted to address the question of how humans reshape vector clip-art inputs. Participants were shown an input shape with labeled and marked vertices, some of which had new positions indicated with arrows. Participants were then asked: "Resize/rescale the object on the left such that the marked vertices are placed at the corresponding new locations as indicated on the right. Feel free to move all other corners so as to best preserve shape." Participants were provided with a task description and a reference example, see supplementary. The study included 5 participants (4 male, 1 female) and 15 representative vector clip-art inputs. Examples of the reshaped inputs that participants drew are shown in Figs. 2 and 9 in our paper; the rest of the study results are included in the supplementary material. Our key qualitative findings are that participants in general are consistent in how they perform reshaping tasks on clip-art images; furthermore, study participants exhibited behaviors that were consistent with prior research such as preferring solutions that avoided or minimized curve rotation, and that locally scaled curves as uniformly as possible. These findings were used to guide the design and implementation of our ALUP algorithm. Our outputs agree with the drawings consistently produced during the study with the exception of the bag (Fig. 9 in our paper), where participants infer an implicit constraint that causes them to fix the height of the buckle in place. By adding that constraint manually, we can achieve results consistent with participant outputs.

B STUDY II: COMPARISON OF RESHAPING ALTERNATIVES

We validate the quality of our results by comparing them to those produced by alternative methods via a comparative study. Study participants were shown input drawings, together with our reshaping result and an alternative reshaping result; the input was shown on top and marked as 'A', and the two reshaping results were placed at the bottom in random order and marked as 'B' and 'C'. Participants were then asked: "The image on the top (A) includes a suggested resizing/rescaling edit indicated via point displacements. The blue points are moved as suggested by the arrows, while the red points are held in place. Mentally perform the suggested resizing/rescaling task. Which of the shapes on the bottom (B) or (C) comes closer to the edit you envisioned?" The answer options were "B", "C", "Both", and "Neither".

The study was conducted remotely, with participants receiving and returning the questionnaires via email. Participants were provided with a task description and shown the same example as in the reshaping intent study; no other explanation was provided. Similar to other perception studies (e.g. [Dominici et al. 2020]) we used a screening question to discard all answers from participants who did not read the task description. The screening question was nearly identical to the example in the task description and compared a ground truth result (unanimously drawn by tracing study participants) to a highly sheared alternative. Two participants failed the screening question. Both the task description and the screening question are in the supplementary material.

We included 15 questions comparing our results against each of the As-Killing-As-Possible method of Solomon et al. [2011], and Adobe's Puppet Warp tool. We included 30 questions comparing our results against our baseline Poisson deformation implementation, as those results come closer to the satisfying the desired reshaping properties we identified. Questions were randomly distributed into three strata, so that each includes 5 comparisons against the two former methods and 10 against the latter. The study had a total of 30 valid participants (17 male, 13 female); each participant answered 20 questions, assigned from one of the three strata. In total we collected 10 answers to each question. All study data is provided in the additional supplemental material.

Fig. 8 in our paper summarizes the study results. Participants preferred ALUP reshapings over the classical Poisson deformation 70% of the time, and preferred the alternative only 11% of the time, they judged both results as equally good 14% of the time; they preferred ALUP reshapings over Solomon et al. [2011] and Puppet Warp overwhelmingly (94% and 90% of the time respectively). We conducted t-tests on the study results and found that the results were highly statistically significant (two-tailed t-tests; $p < 0.001$ for comparisons vs. Poisson, vs. Solomon et al. [2011], and vs. Puppet Warp). We conclude that our ALUP reshaping algorithm produces outputs that are more consistent with participant expectations than those produced by prior approaches.

Poisson Deformation. Our implementation of the baseline Poisson deformation approach follows [Cohen-Or et al. 2015]: we deform the input curve network by finding new vertex positions that minimize

Authors' addresses: Chrystiano Araújo, University of British Columbia, Canada, araujoc@cs.ubc.ca; Nicholas Vining, University of British Columbia, Canada , NVIDIA, Canada, nvining@cs.ubc.ca; Enrique Rosales, University of British Columbia, Canada, albertr@cs.ubc.ca; Giorgio Gori, Adobe Research, USA, gori@adobe.com; Alla Sheffer, University of British Columbia, Canada, sheffa@cs.ubc.ca.

$\sum_{\langle i,j\rangle \in E} 1/L_{avg}||(v_j - v_i) - (v_j^0 - v_i^0)||^2$ with appropriate handle constraints held in place with weight w_c.

C STUDY III: COMPARISON VS. MANUAL RESHAPING

We further validate the quality of our results by comparing them to three manual reshapings performed by a professional artist. The artist was given the inputs and handle constraints in Figs. 1 and 3 (crown, cactus, feeder); it took an artist 45 min to generate the first output, and about 15 minutes each for the other two. Study participants were shown input drawings, together with our reshaping result and an alternative reshaping result produced manually by the artist. Following the methodology of study 2, the input was shown on top and marked as 'A', and the two reshaping results were placed at the bottom in random order and marked as 'B' and 'C'. Participants were then asked: "The image on the top (A) includes a suggested resizing/rescaling edit indicated via point displacements. The blue points are moved as suggested by the arrows, while the red points are held in place. Mentally perform the suggested resizing/rescaling task. Which of the shapes on the bottom (B) or (C) comes closer to the edit you envisioned?" The answer options were "B", "C", "Both", and "Neither". The study had a total of 10 participants (6 male, 4 female). All study data is provided in the additional supplemental material.

Participants preferred ALUP reshapings over the artist efforts 60% of the time, judged us on par 27% of the time, and preferred the artist result only 13%. of the time. We confirm the statistical significance of our results by running a paired two-tailed t-test, which found that our results were statistically significant ($p < 0.005$). We therefore conclude that our ALUP reshaping artist produces outputs that are at least on par with those created by a professional artist, and in this case significantly outperformed their efforts.

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