

Functional Blueprints: An Approach to Modularity in Grown Systems: Supplementary Information

Jacob Beal

Received: date / Accepted: date

1 Distortions

The experimental distortions are produced using the following programs:

```
(def parabolic-distort (start time)
  (let* ((loc (coord)) (x (once (1st loc))) (y (once (2nd loc))))
    (let ((p1 (tup (once x) (once y)))
      (p2 (tup (* x 4) (+ (* y 0.5) (* -0.02 x x)))))
      (let ((t (timer)))
        (if (< t start)
            (tup 0 0)
            (if (< (mod (- t start) (* 2 time)) time)
                (mov (* (/ 1 time) (- p2 p1)))
                (mov (* (/ 1 time) (- p1 p2)))))))
    (def curl-distort (start time)
      (let* ((loc (coord)) (x (once (1st loc))) (y (once (2nd loc))))
        (let ((p1 (tup (once x) (once y)))
          (p2 (tup (+ (* 0.5 x) (* y 4))
            (* (+ 30 (/ (+ y 50) 1)) (cos (* 4 3.14159 (/ y 100))))
            (* (+ 30 (/ (+ y 50) 1)) (sin (* 4 3.14159 (/ y 100)))))))
          (let ((t (timer)))
            (if (< t start)
                (tup 0 0)
                (if (< (mod (- t start) (* 2 time)) time)
                    (mov (* (/ 1 time) (- p2 p1)))
                    (mov (* (/ 1 time) (- p1 p2)))))))
    (def split-distort (start time)
      (let* ((loc (coord)) (x (once (1st loc))) (y (once (2nd loc))))
        (let ((p1 (tup (once x) (once y)))
          (p2 (tup (+ (* (+ 1.5 (* y 0.01)) x)
```

```

(if (< y -30) 0 (* 3 (pow (+ y 30) 0.5) (sign x))))
y)))
(let ((t (timer)))
(if (< t start)
(tup 0 0)
(if (< (mod (- t start) (* 2 time)) time)
(mov (* (/ 1 time) (- p2 p1)))
(mov (* (/ 1 time) (- p1 p2)))))))

```

2 Shortest Path Distortion Experiments

This set of experiments are run under the following conditions:

- Parabolic distortion of square: proto -dim 400 200 -dist-dim -50 50 -50 50 "(all (parabolic-distort 50 500) (shortestpath-expt 0))" -m -s 1 -n 2000 -T -sharp-connections -c -r 10 -l -rad 0.5 -hide-body -led-blend
- 3D curl distortion of square: proto -dim 500 300 -dist-dim -50 50 -50 50 0 0 "(all (curl-distort 50 2000) (shortestpath-expt 1))" -m -s 1 -n 2000 -T -3d -sharp-connections -c -r 15 -l -rad 0.75 -hide-body -led-blend
- Parabolic distortion of complex shape: proto -dim 400 200 -dist-dim -50 50 -50 50 "(all (oddshape) (parabolic-distort 50 500) (shortestpath-expt 0))" -L simple-life-cycle -m -s 1 -n 2000 -T -sharp-connections -c -r 10 -l -rad 0.5 -hide-body -led-blend
- Splitting distortion of complex shape: proto -dim 400 100 -dist-dim -50 50 -50 50 -L simple-life-cycle "(all (oddshape) (split-distort 50 500) (shortestpath-expt 0))" -m -s 1 -n 2000 -T -sharp-connections -c -r 8 -l -rad 0.5 -hide-body -led-blend

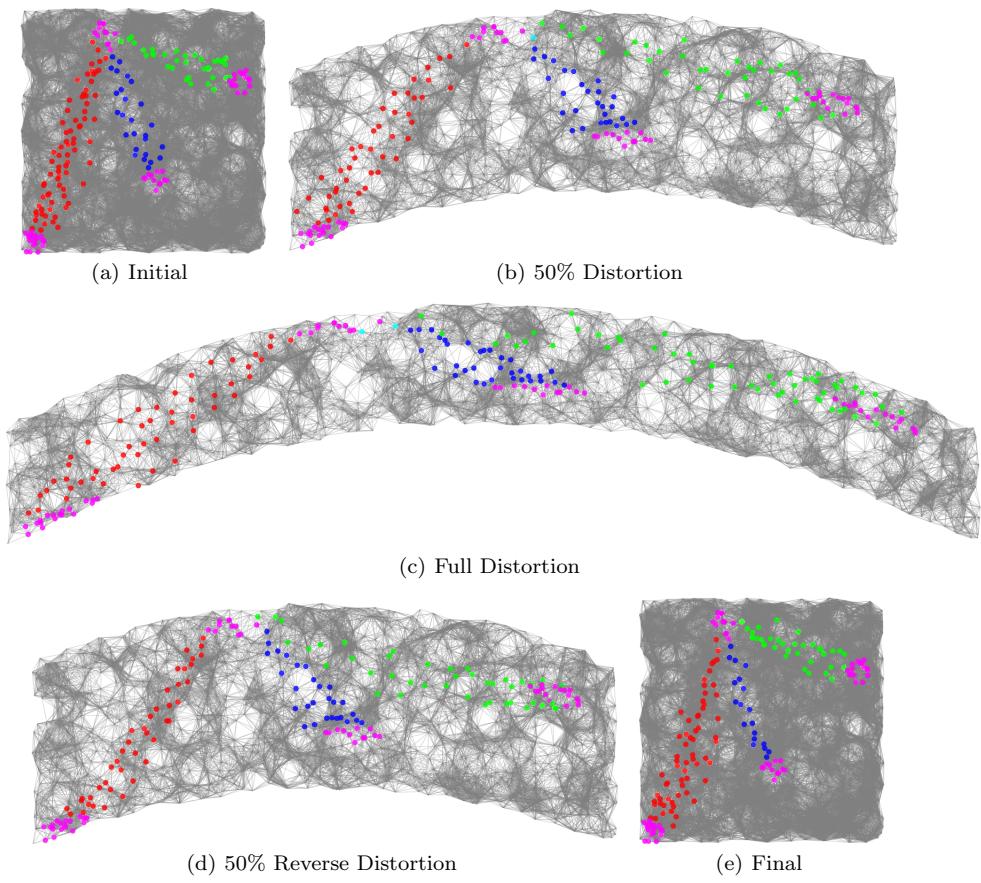


Fig. 1 Shortest path program executing on a square under parabolic distortion

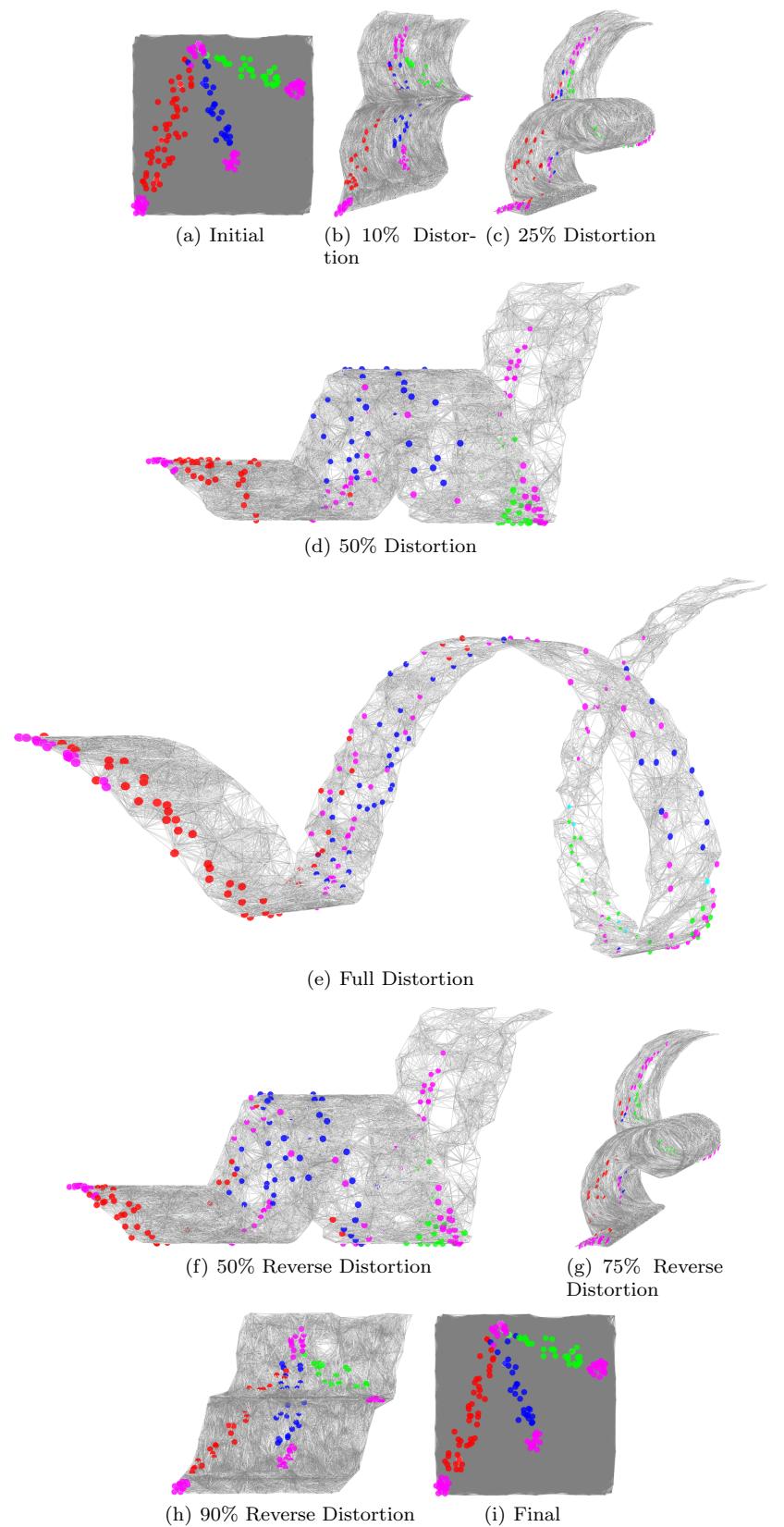


Fig. 2 Shortest path program executing on a square under 3D curl distortion

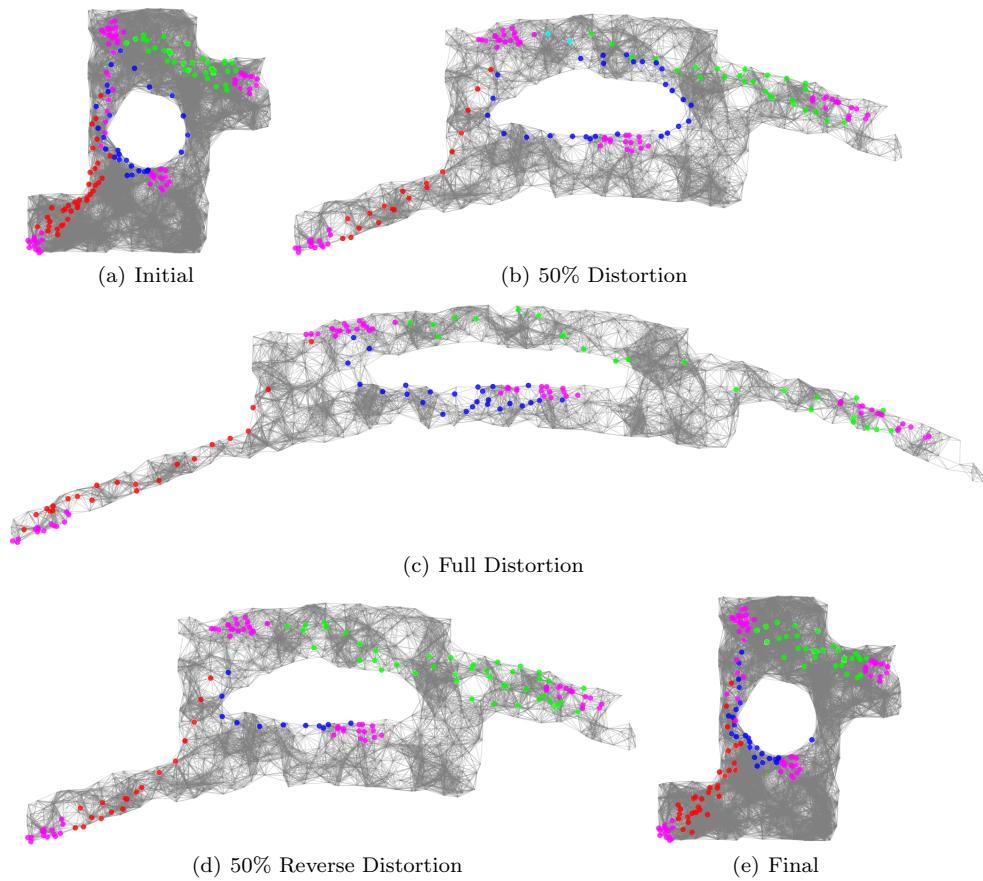


Fig. 3 Shortest path program executing on a complex shape under parabolic distortion

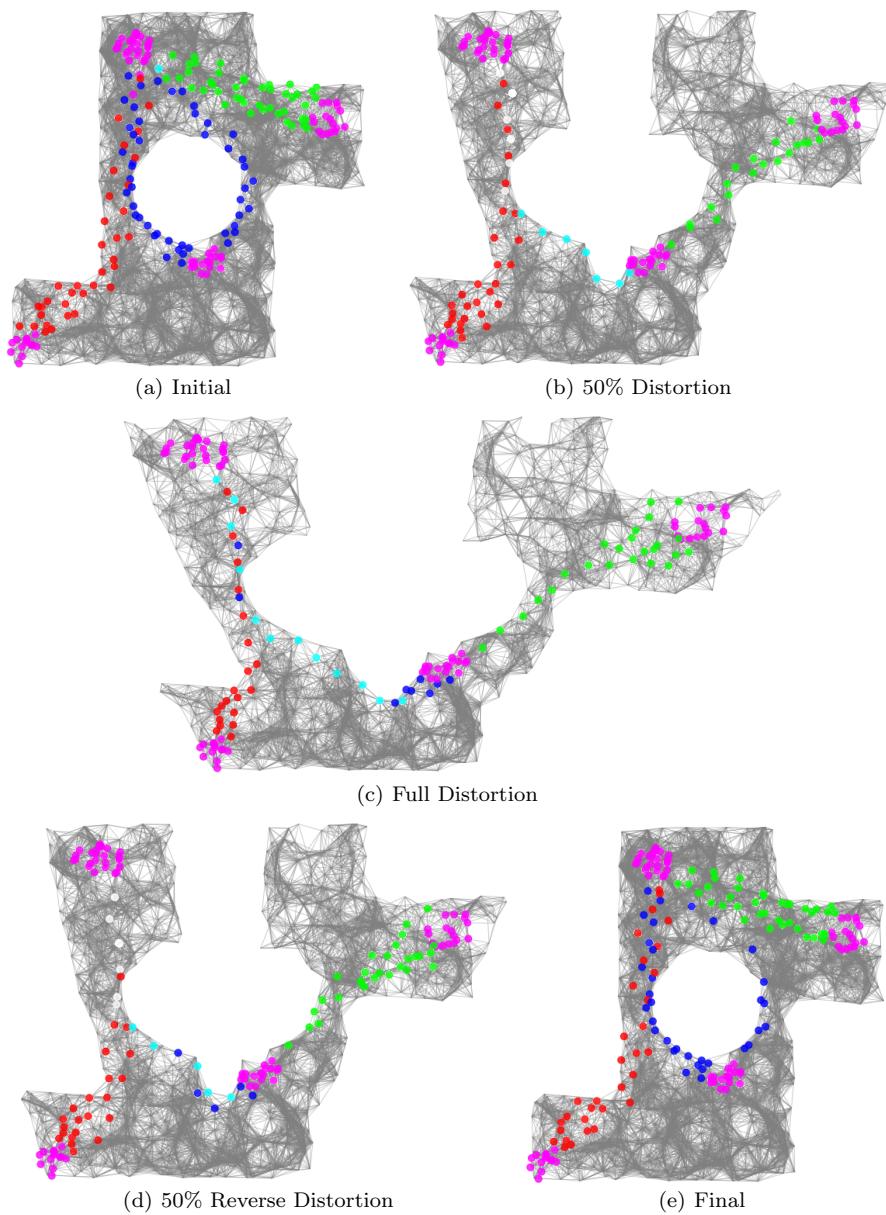


Fig. 4 Shortest path program executing on a complex shape under splitting distortion

3 Bisector Distortion Experiments

This set of experiments are run under the following conditions:

- Parabolic distortion of square: proto -dim 400 200 -dist-dim -50 50 -50 50 "(all (parabolic-distort 50 500) (bisector-expt 0))" -m -s 1 -n 2000 -T -sharp-connections -c -r 10 -l -rad 1 -hide-body
- 3D curl distortion of square: proto -dim 500 300 -dist-dim -50 50 -50 50 0 0 "(all (curl-distort 50 1000) (bisector-expt 1))" -m -s 1 -n 2000 -T -3d -sharp-connections -c -r 15 -l -rad 1.5 -hide-body
- Parabolic distortion of complex shape: proto -dim 400 200 -dist-dim -50 50 -50 50 "(all (oddshape) (parabolic-distort 50 500) (bisector-expt 0))" -L simple-life-cycle -m -s 1 -n 2000 -T -sharp-connections -c -r 10 -l -rad 1 -hide-body
- Splitting distortion of complex shape: proto -dim 400 100 -dist-dim -50 50 -50 50 -L simple-life-cycle "(all (oddshape) (split-distort 50 500) (bisector-expt 0))" -m -s 1 -n 2000 -T -sharp-connections -c -r 8 -l -rad 1 -hide-body

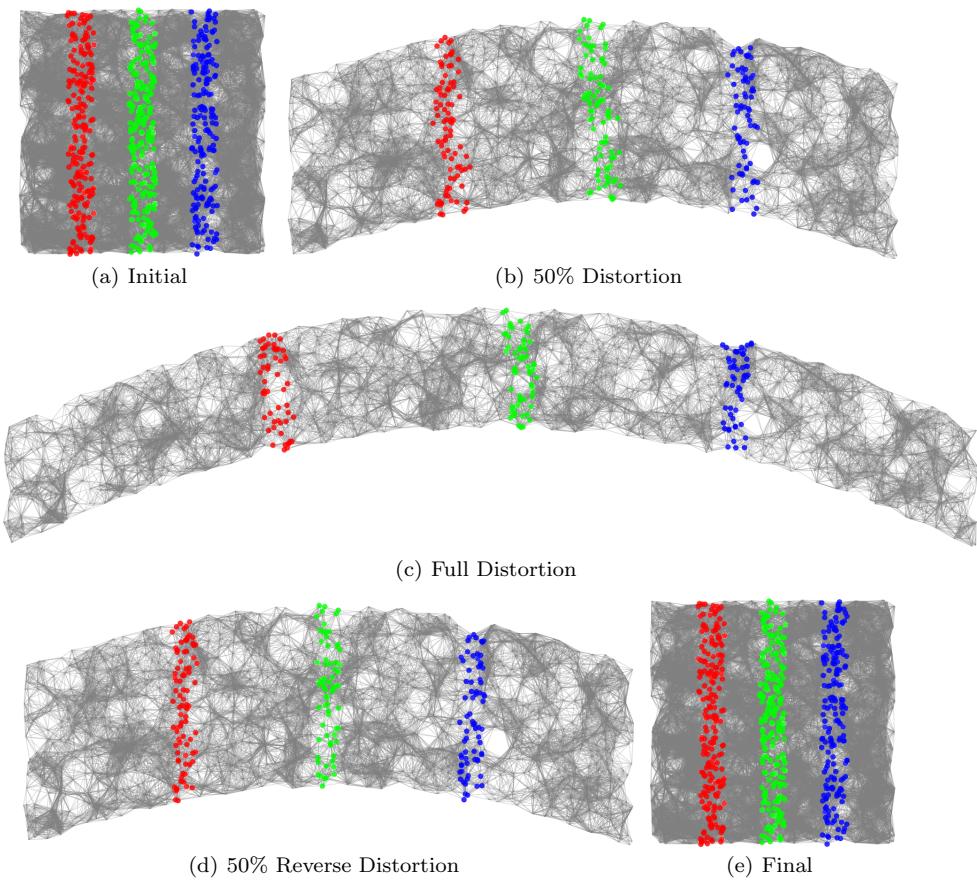


Fig. 5 Bisector program executing on a square under parabolic distortion

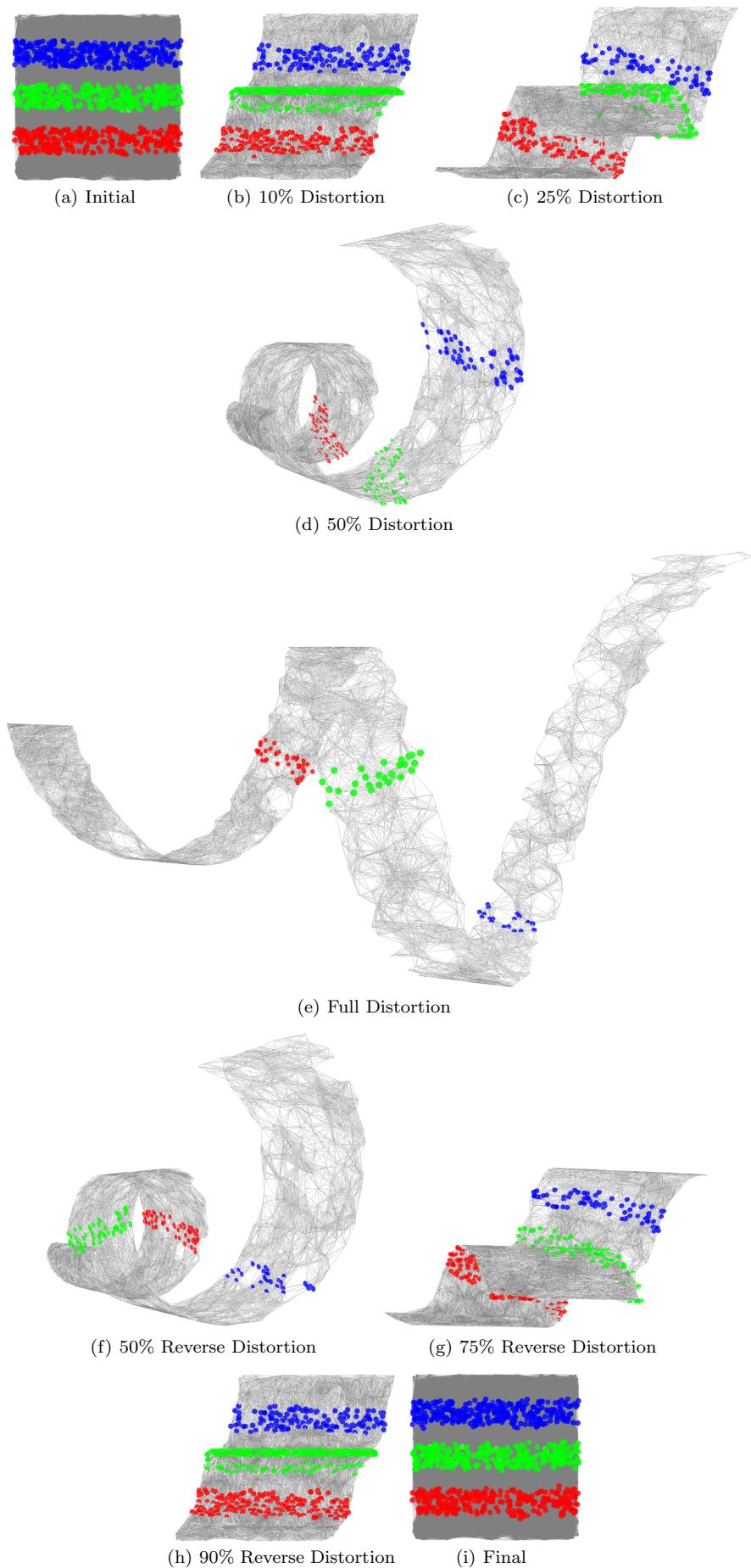


Fig. 6 Bisector program executing on a square under 3D curl distortion

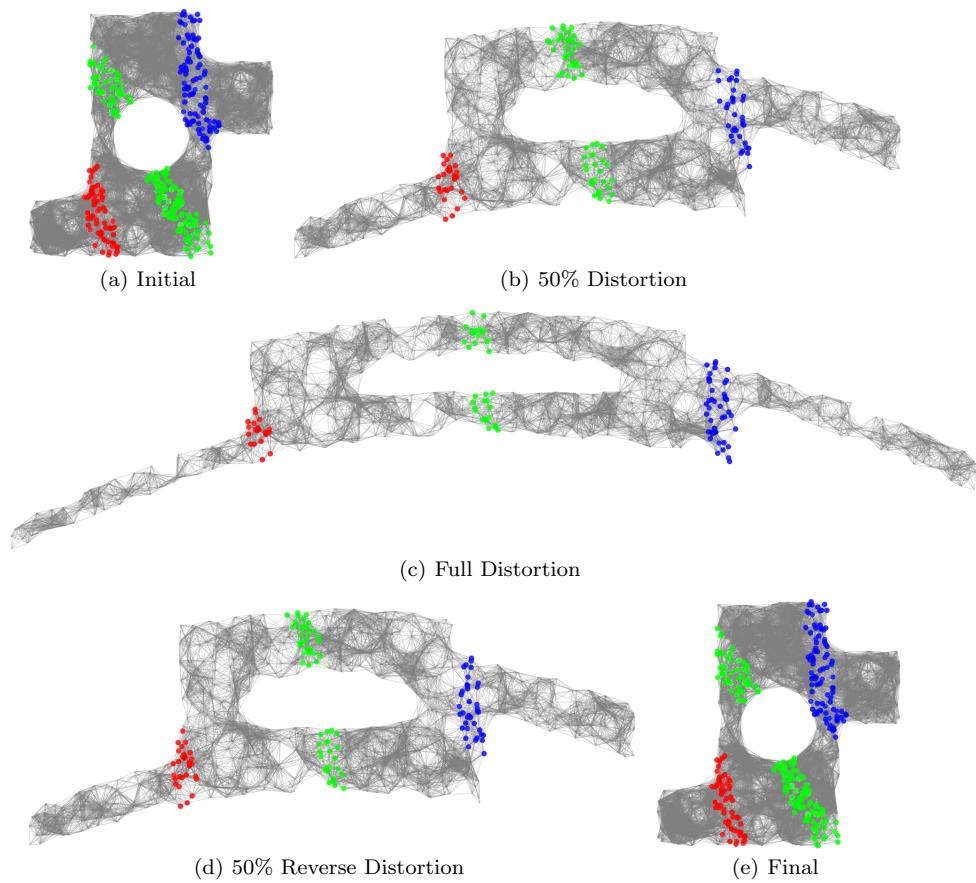


Fig. 7 Bisector program executing on a complex shape under parabolic distortion

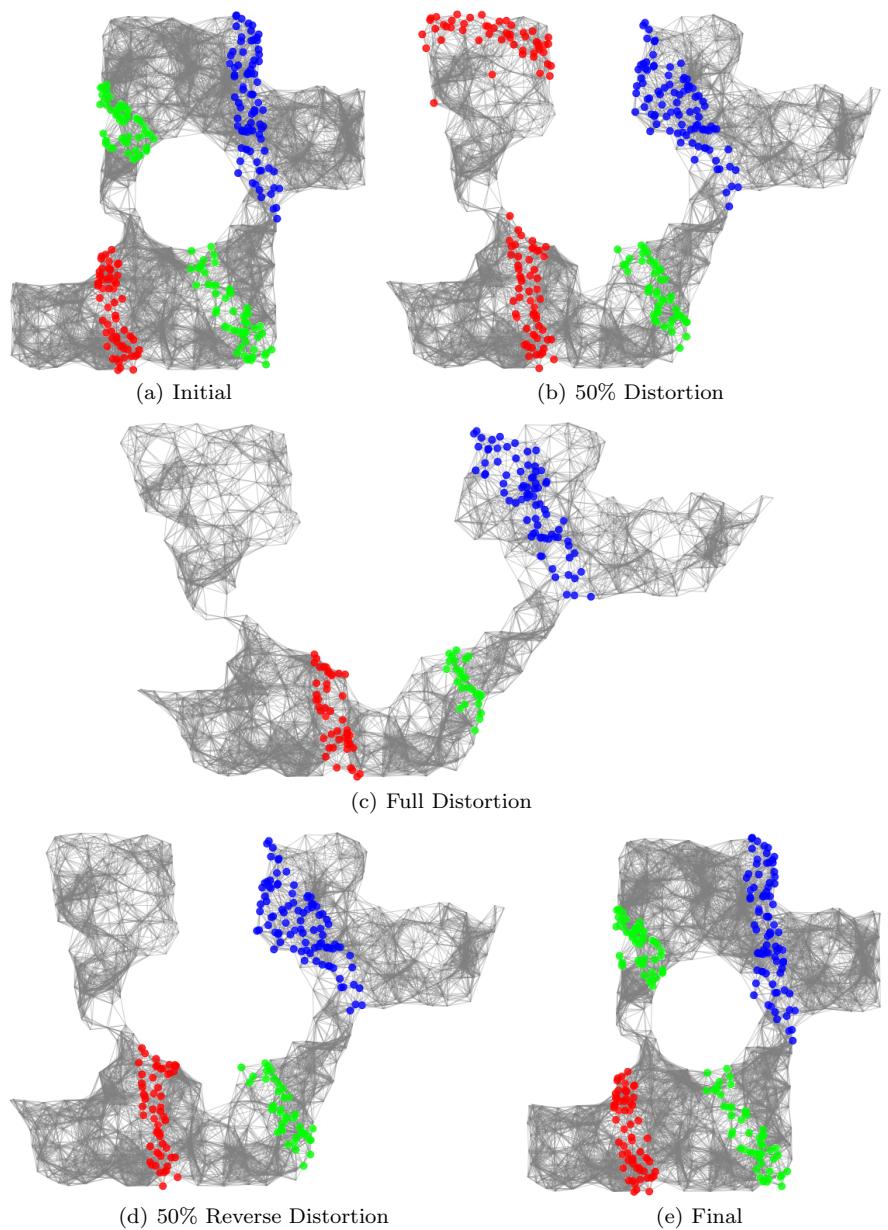


Fig. 8 Bisector program executing on a complex shape under splitting distortion

4 Dilate Distortion Experiments

This set of experiments are run under the following conditions:

- Parabolic distortion of square: proto -dim 400 200 -dist-dim -50 50 -50 50 "(all (parabolic-distort 50 500) (dilation-expt 0))" -m -s 1 -n 2000 -T -sharp-connections -c -r 10 -l -rad 0.5 -hide-body -DD fixedpt -45 -45 -fixedpt 40 20 -fixedpt -15 40 -fixedpt 5 -30 -led-blend
- 3D curl distortion of square: proto -dim 500 300 -dist-dim -50 50 -50 50 0 0 "(all (curl-distort 50 500) (dilation-expt 1))" -m -s 1 -n 2000 -T -3d -sharp-connections -c -r 15 -l -rad 0.75 -hide-body -DD fixedpt -45 -45 -fixedpt 40 20 -fixedpt -15 40 -fixedpt 5 -30 -led-blend
- Parabolic distortion of complex shape: proto -dim 400 200 -dist-dim -50 50 -50 50 "(all (oddshape) (parabolic-distort 50 500) (dilation-expt 0))" -L simple-life-cycle -m -s 1 -n 2000 -T -sharp-connections -c -r 10 -l -rad 0.5 -hide-body -DD fixedpt -45 -45 -fixedpt 40 20 -fixedpt -15 40 -fixedpt 5 -30 -led-blend
- Splitting distortion of complex shape: proto -dim 400 100 -dist-dim -50 50 -50 50 -L simple-life-cycle "(all (oddshape) (split-distort 50 500) (dilation-expt 0))" -m -s 1 -n 2000 -T -sharp-connections -c -r 8 -l -rad 0.5 -hide-body -DD fixedpt -45 -45 -fixedpt 40 20 -fixedpt -15 40 -fixedpt 5 -30 -led-blend

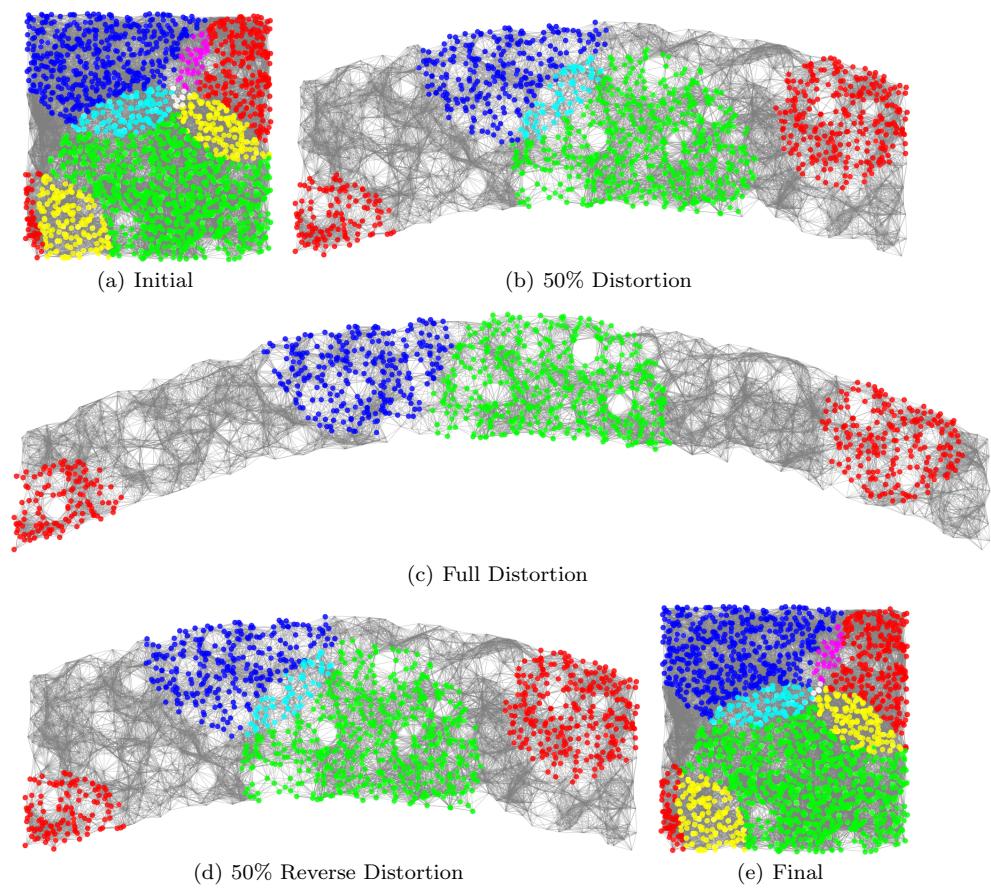


Fig. 9 Dilation program executing on a square under parabolic distortion

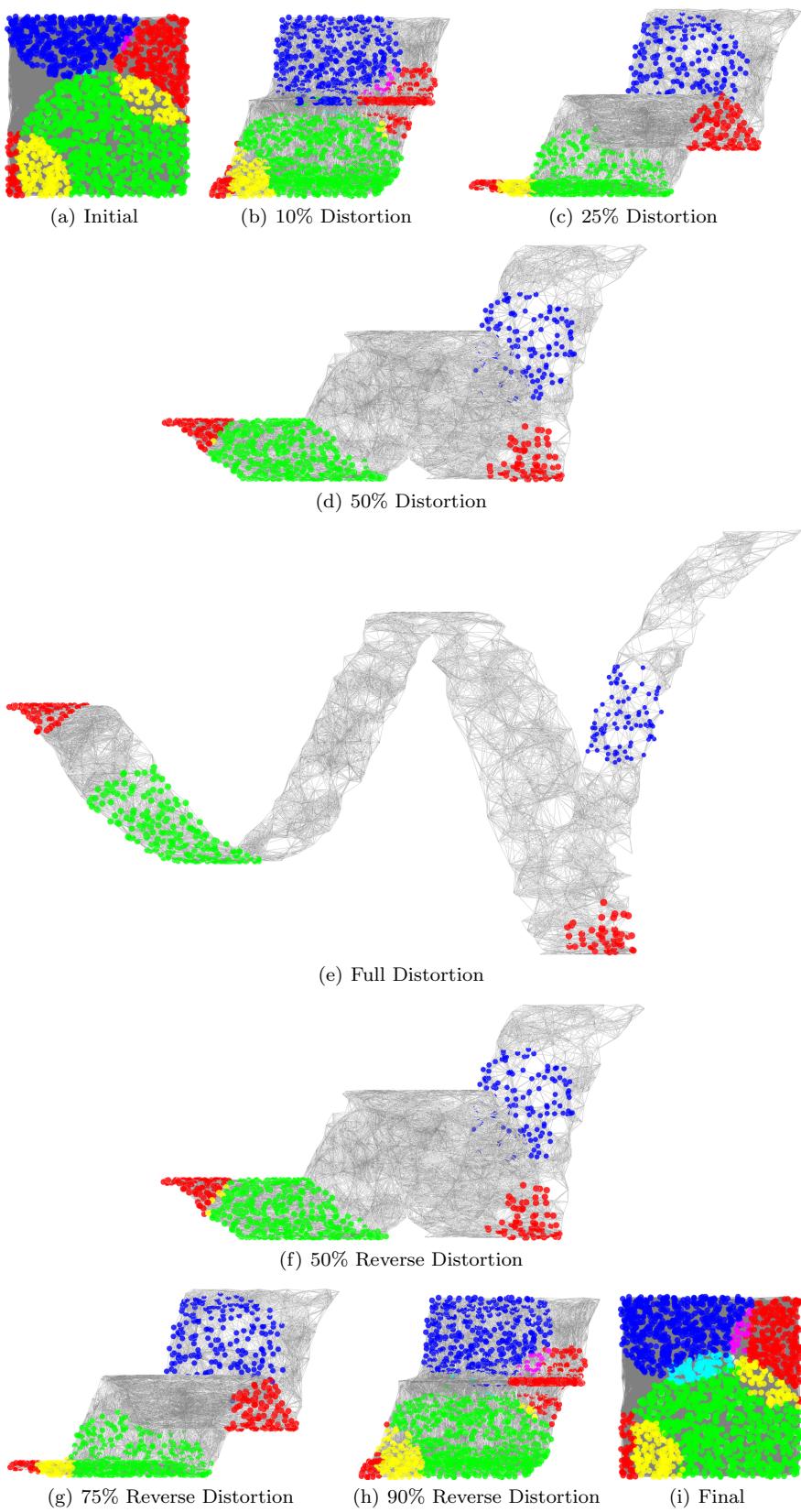


Fig. 10 Dilation program executing on a square under 3D curl distortion

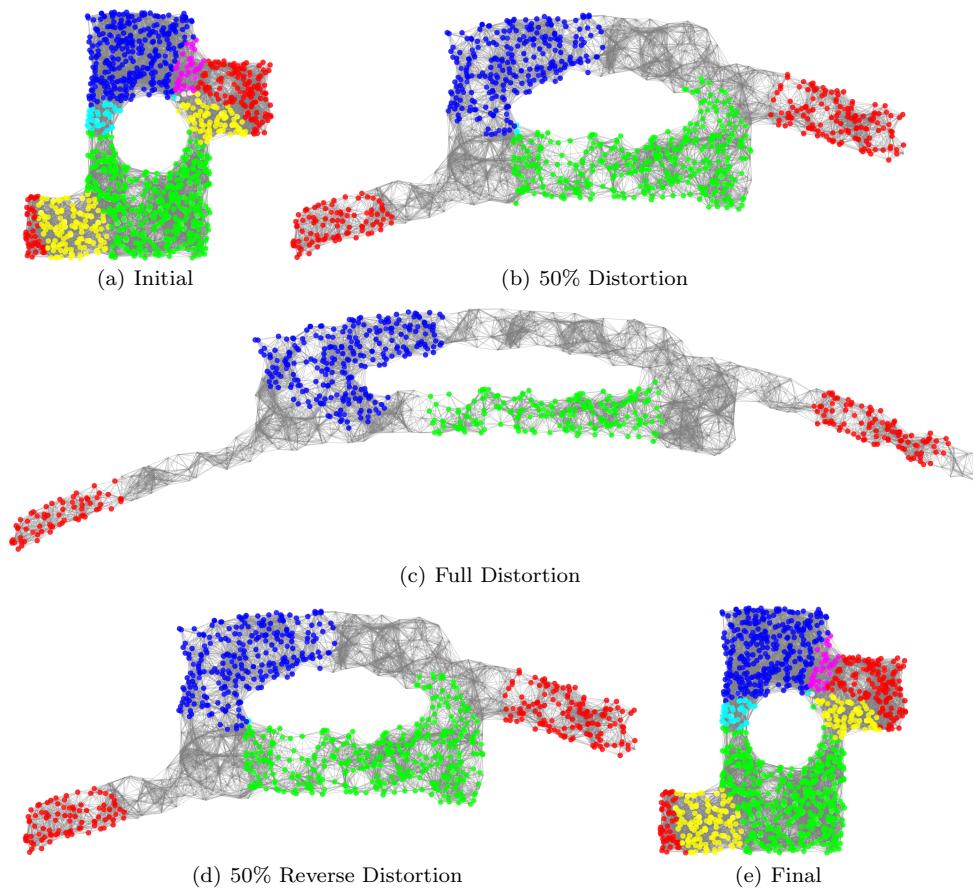


Fig. 11 Dilation program executing on a complex shape under parabolic distortion

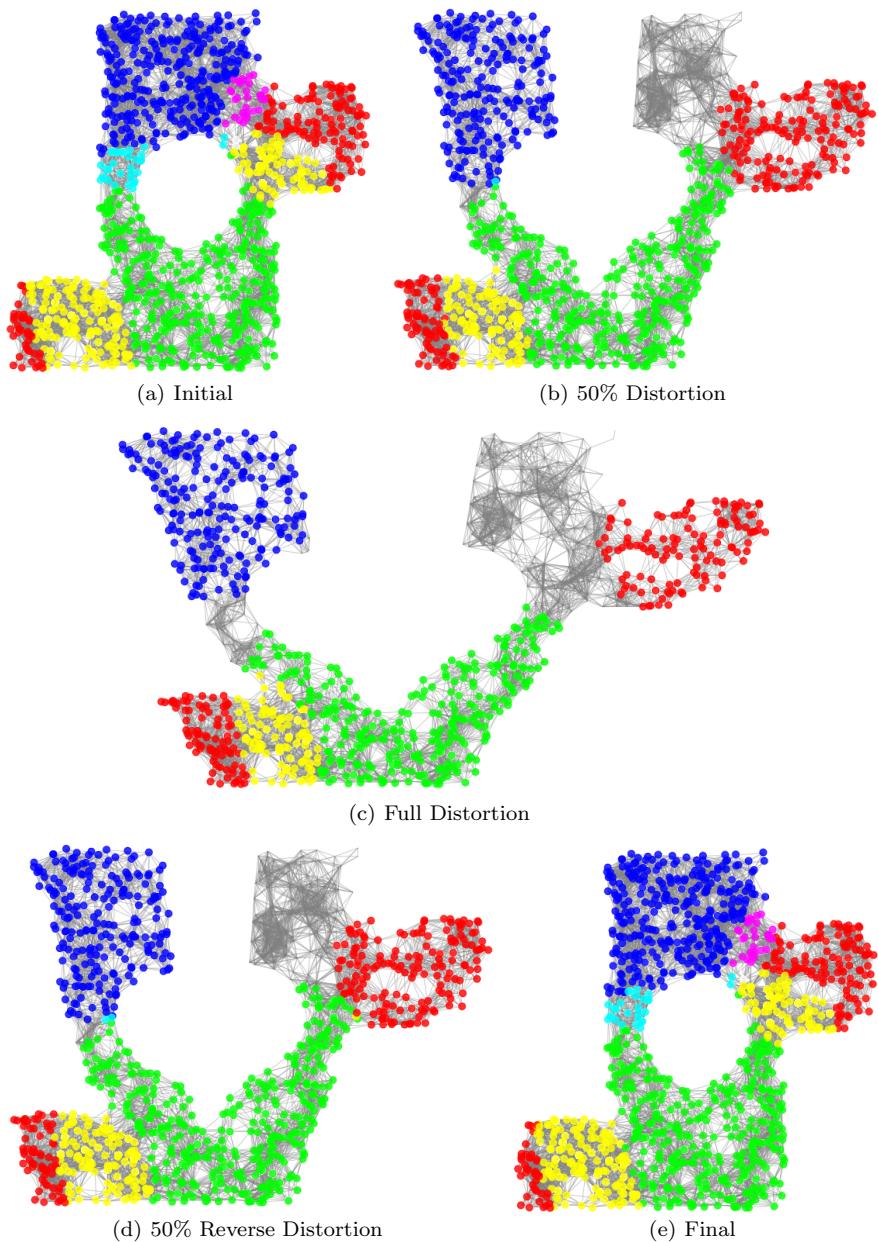


Fig. 12 Dilation program executing on a complex shape under splitting distortion

5 Symmetry Break Distortion Experiments

This set of experiments are run under the following conditions:

- Parabolic distortion of square: proto -dim 400 200 -dist-dim -50 50 -50 50 "(all (parabolic-distort 200 500) (symmetry-break-expt))" -m -s 1 -n 2000 -T -sharp-connections -c -r 10 -l -rad 0.5 -hide-body -led-blend
- 3D curl distortion of square: proto -dim 500 300 -dist-dim -50 50 -50 50 0 0 "(all (curl-distort 200 1000) (symmetry-break-expt))" -m -s 1 -n 2000 -T -3d -sharp-connections -c -r 15 -l -rad 0.75 -hide-body -led-blend
- Parabolic distortion of complex shape: proto -dim 400 200 -dist-dim -50 50 -50 50 "(all (oddshape) (parabolic-distort 200 500) (symmetry-break-expt))" -L simple-life-cycle -m -s 1 -n 2000 -T -sharp-connections -c -r 10 -l -rad 0.5 -hide-body -led-blend
- Splitting distortion of complex shape: proto -dim 400 100 -dist-dim -50 50 -50 50 -L simple-life-cycle "(all (oddshape) (split-distort 200 500) (symmetry-break-expt))" -m -s 1 -n 2000 -T -sharp-connections -c -r 8 -l -rad 0.5 -hide-body -led-blend

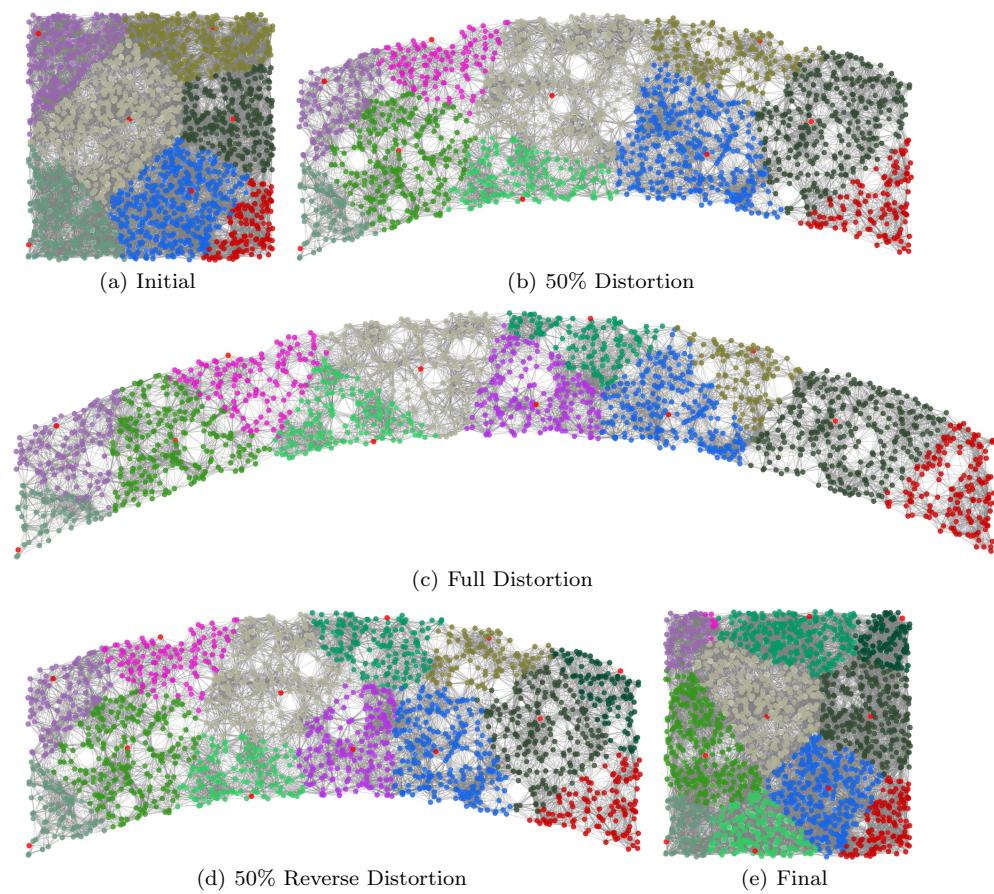


Fig. 13 Symmetry break program executing on a square under parabolic distortion

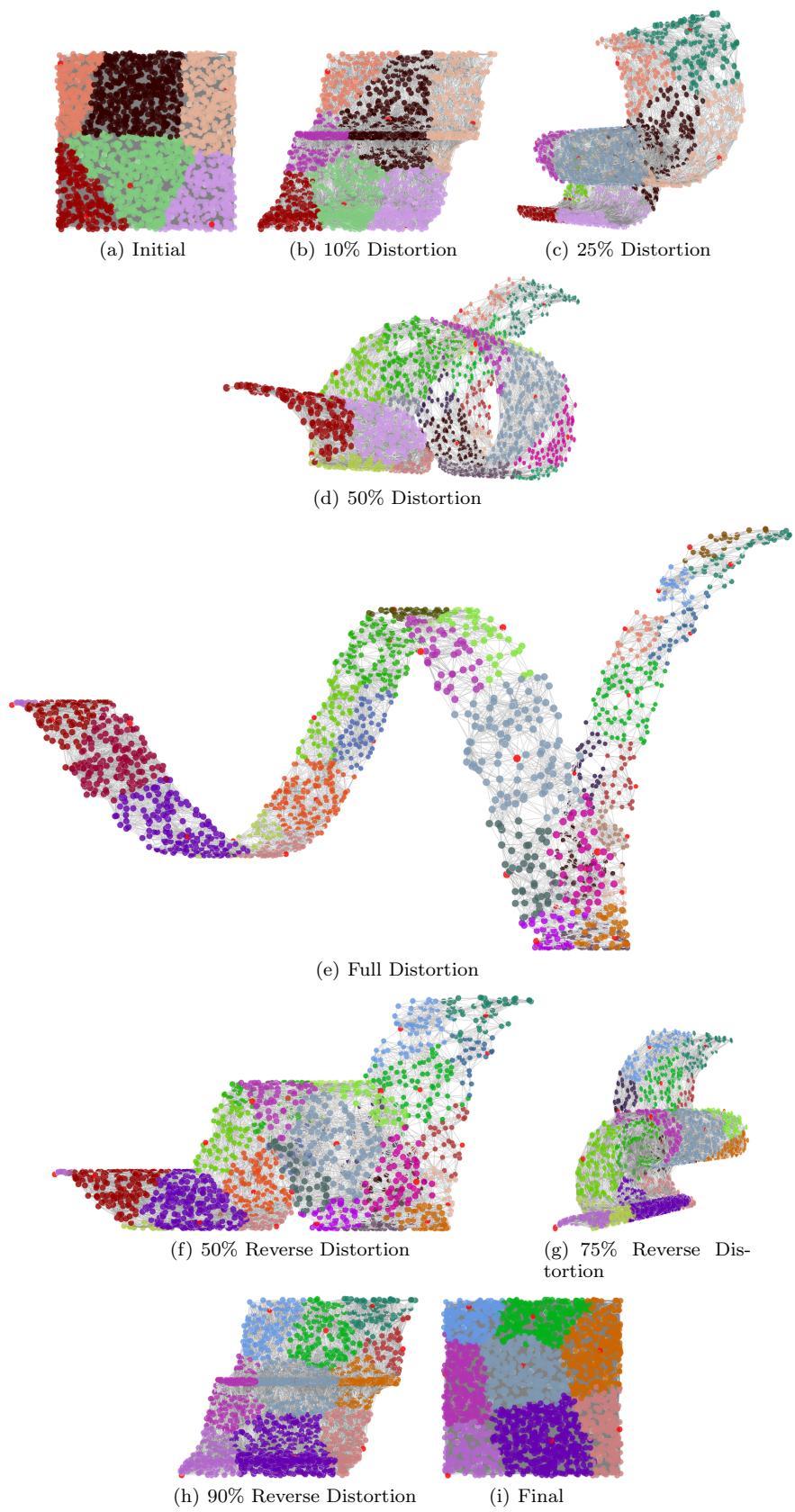


Fig. 14 Symmetry break program executing on a square under 3D curl distortion

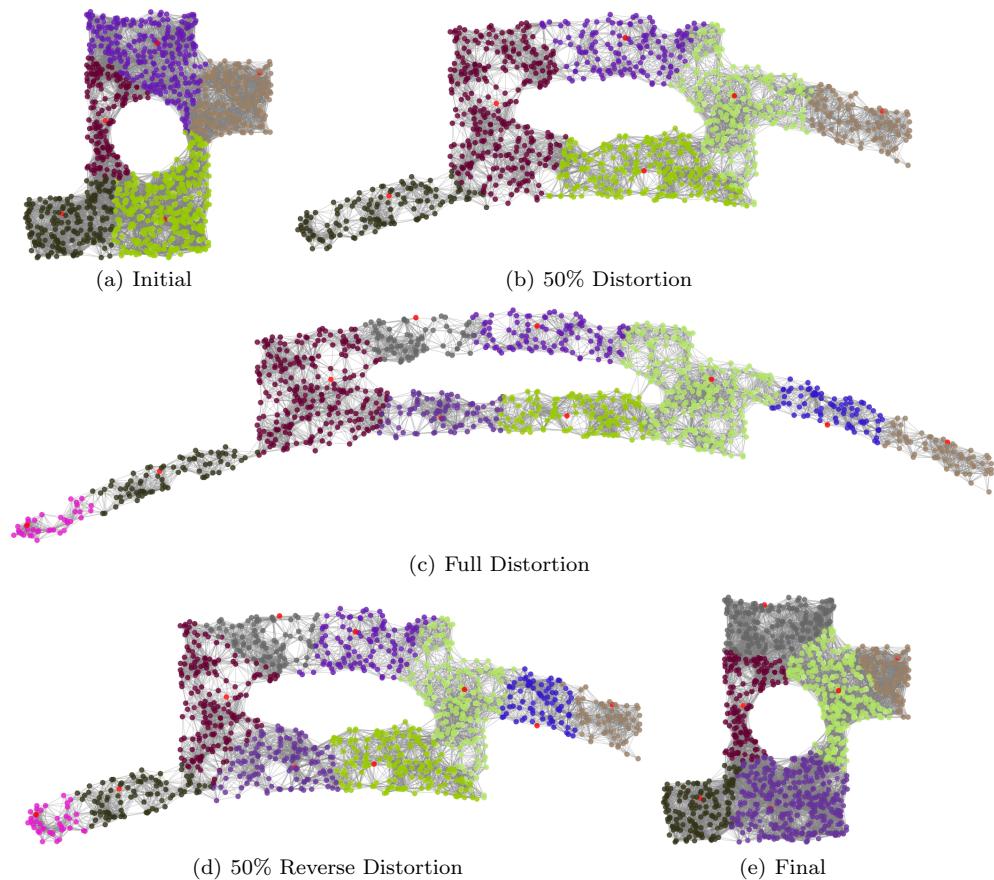


Fig. 15 Symmetry break program executing on a complex shape under parabolic distortion

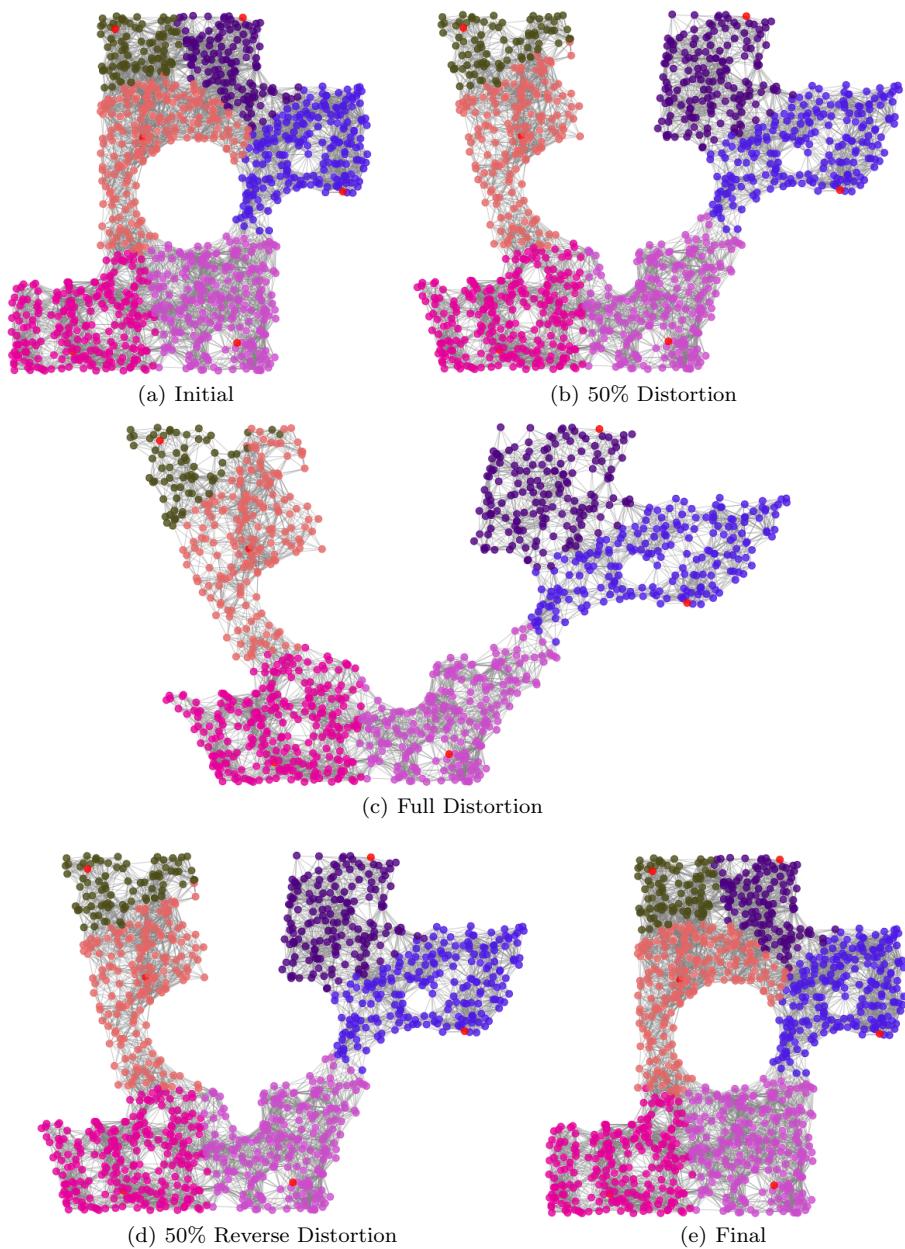


Fig. 16 Symmetry break program executing on a complex shape under splitting distortion

6 Tiled Bisector Distortion Experiments

This set of experiments are run under the following conditions:

- Parabolic distortion of square: proto -dim 400 200 -dist-dim -50 50 -50 50 "(all (parabolic-distort 200 500) (tilebisect-expt 0))" -m -s 1 -n 2000 -T -sharp-connections -c -r 10 -l -rad 1 -hide-body
- 3D curl distortion of square: proto -dim 500 300 -dist-dim -50 50 -50 50 0 0 "(all (curl-distort 200 2000) (tilebisect-expt 0))" -m -s 1 -n 2000 -T -3d -sharp-connections -c -r 15 -l -rad 1.5 -hide-body
- Parabolic distortion of complex shape: proto -dim 400 200 -dist-dim -50 50 -50 50 "(all (oddshape) (parabolic-distort 200 500) (tilebisect-expt 1))" -L simple-life-cycle -m -s 1 -n 2000 -T -sharp-connections -c -r 10 -l -rad 1 -hide-body
- Splitting distortion of complex shape: proto -dim 400 100 -dist-dim -50 50 -50 50 -L simple-life-cycle "(all (oddshape) (split-distort 200 500) (tilebisect-expt 1))" -m -s 1 -n 2000 -T -sharp-connections -c -r 8 -l -rad 1 -hide-body

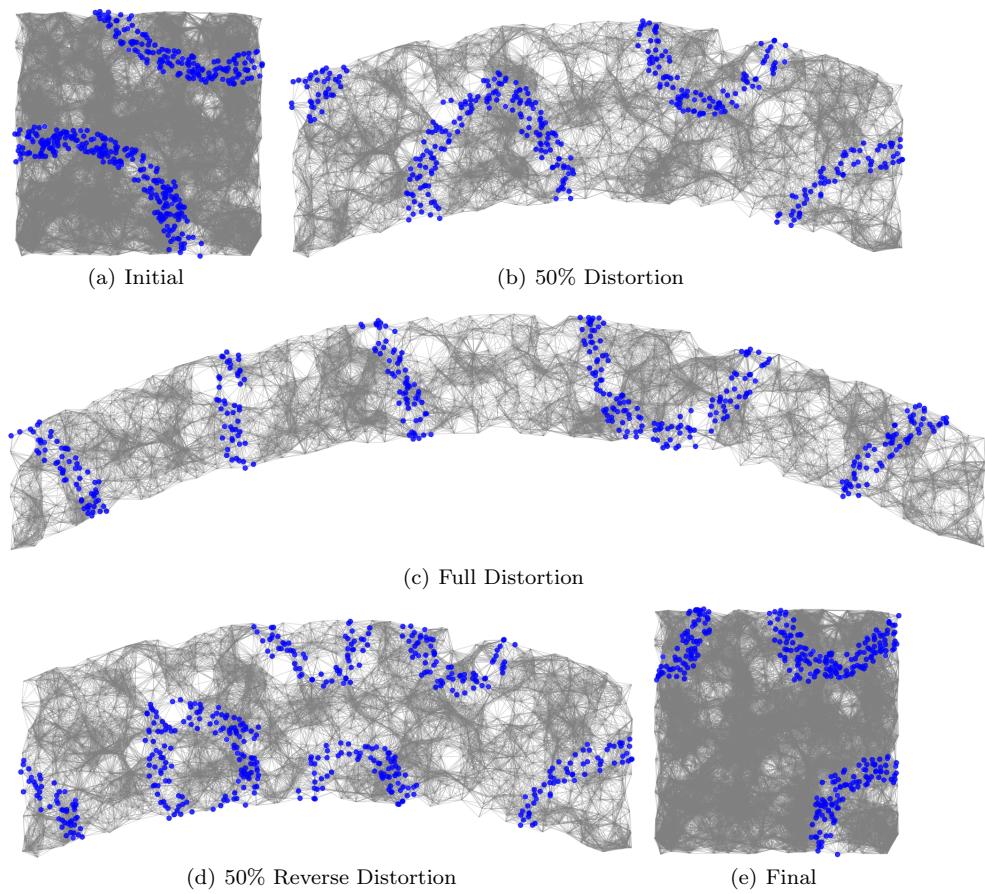


Fig. 17 Tiled bisector program executing on a square under parabolic distortion



Fig. 18 Tiled bisector program executing on a square under 3D curl distortion

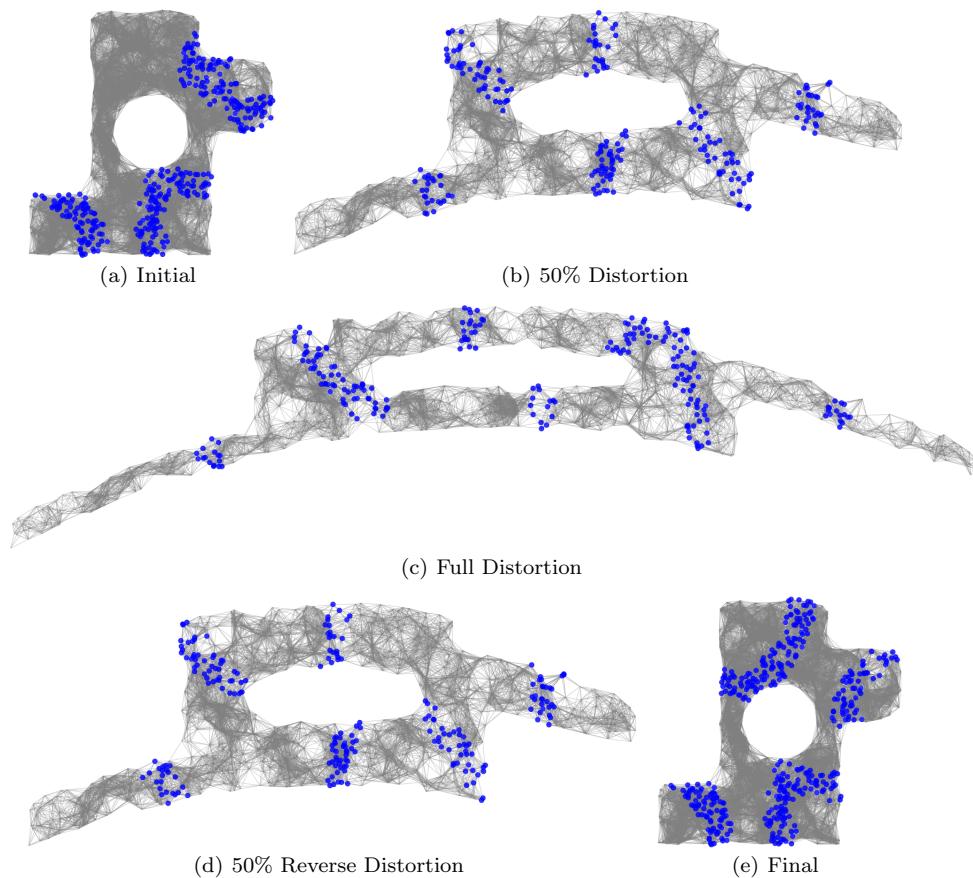


Fig. 19 Tiled bisector program executing on a complex shape under parabolic distortion

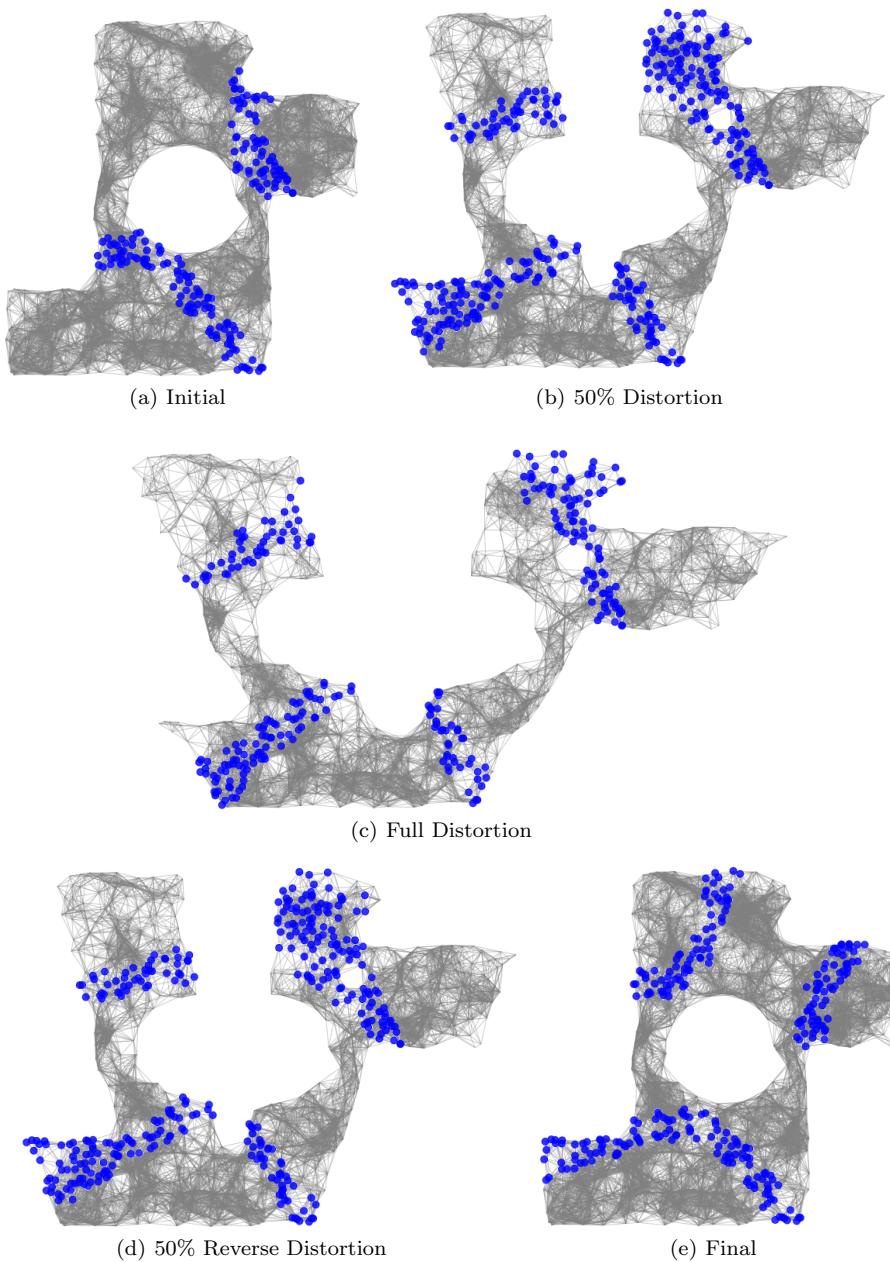


Fig. 20 Tiled bisector program executing on a complex shape under splitting distortion

7 Polka Dot Distortion Experiments

This set of experiments are run under the following conditions:

- Parabolic distortion of square: proto -dim 400 200 -dist-dim -50 50 -50 50 "(all (parabolic-distort 200 500) (polkadot-expt))" -m -s 1 -n 2000 -T -sharp-connections -c -r 10 -l -rad 1 -hide-body
- 3D curl distortion of square: proto -dim 500 300 -dist-dim -50 50 -50 50 0 0 "(all (curl-distort 200 1000) (polkadot-expt))" -m -s 1 -n 2000 -T -3d -sharp-connections -c -r 15 -l -rad 1.5 -hide-body
- Parabolic distortion of complex shape: proto -dim 400 200 -dist-dim -50 50 -50 50 "(all (oddshape) (parabolic-distort 200 500) (polkadot-expt))" -L simple-life-cycle -m -s 1 -n 2000 -T -sharp-connections -c -r 10 -l -rad 1 -hide-body
- Splitting distortion of complex shape: proto -dim 400 100 -dist-dim -50 50 -50 50 -L simple-life-cycle "(all (oddshape) (split-distort 200 500) (polkadot-expt))" -m -s 1 -n 2000 -T -sharp-connections -c -r 8 -l -rad 1 -hide-body

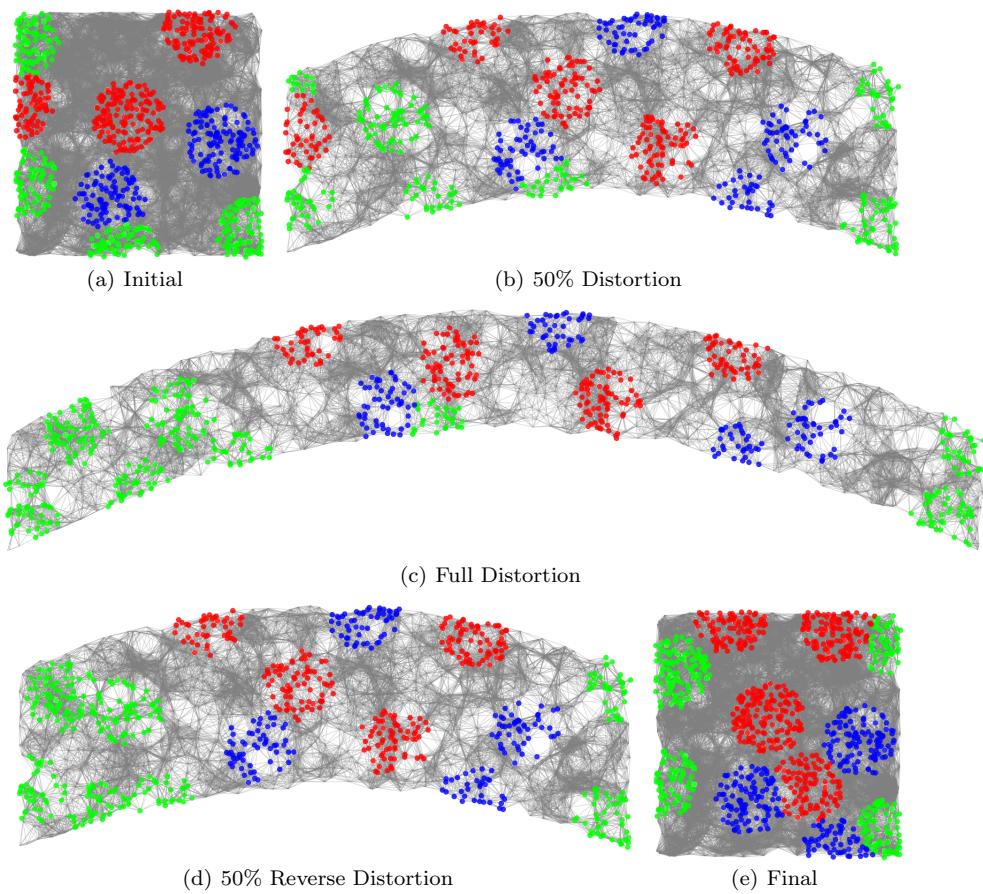


Fig. 21 Polka dot program executing on a square under parabolic distortion

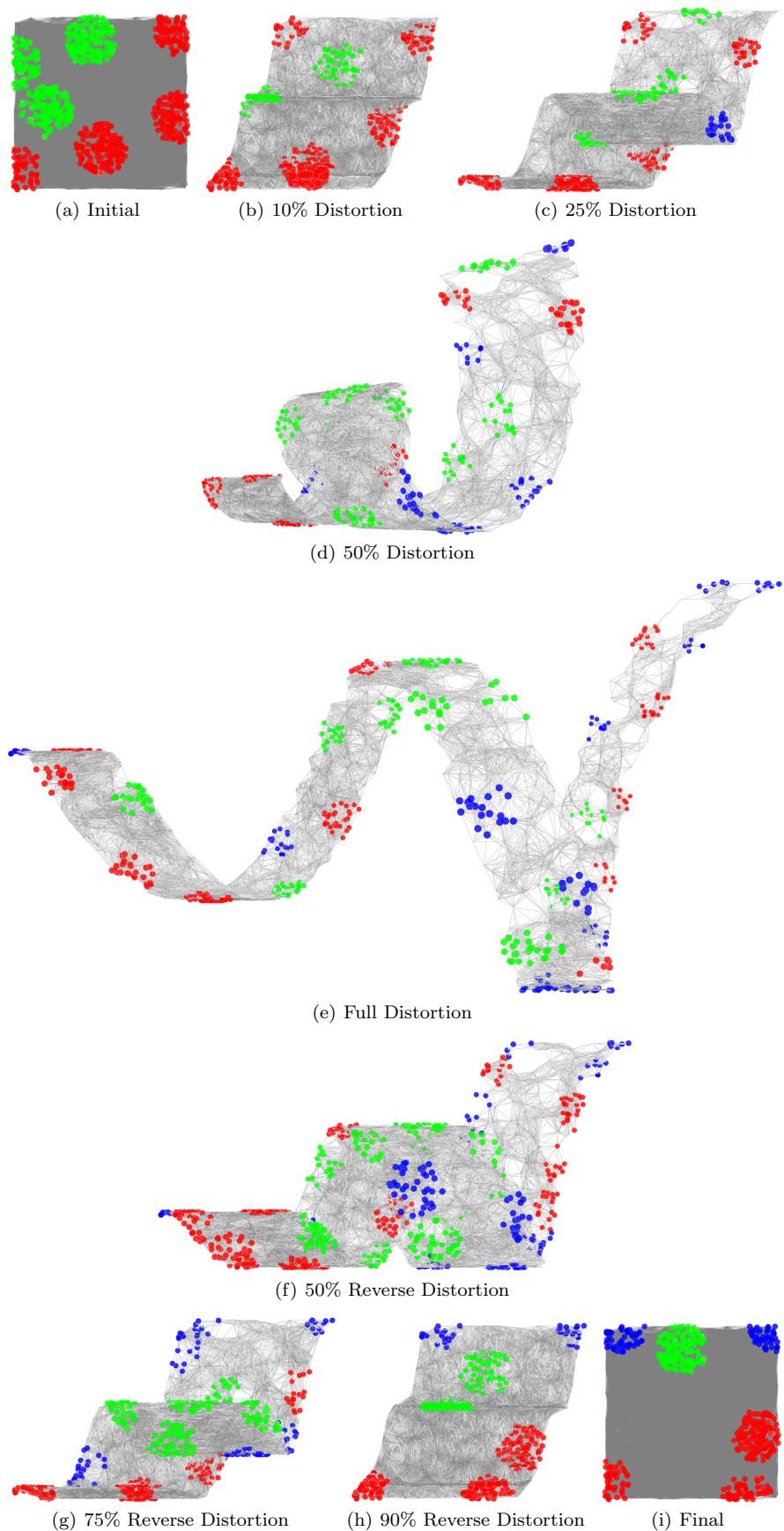


Fig. 22 Polka dot program executing on a square under 3D curl distortion

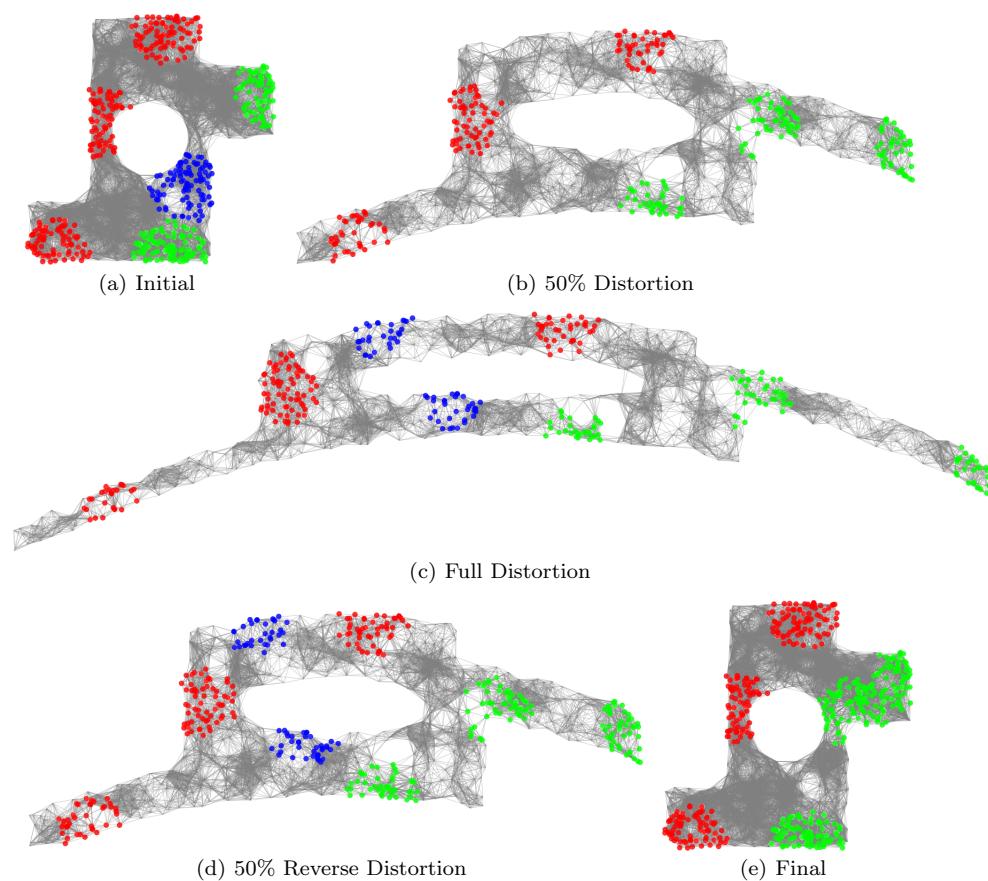


Fig. 23 Polka dot program executing on a complex shape under parabolic distortion

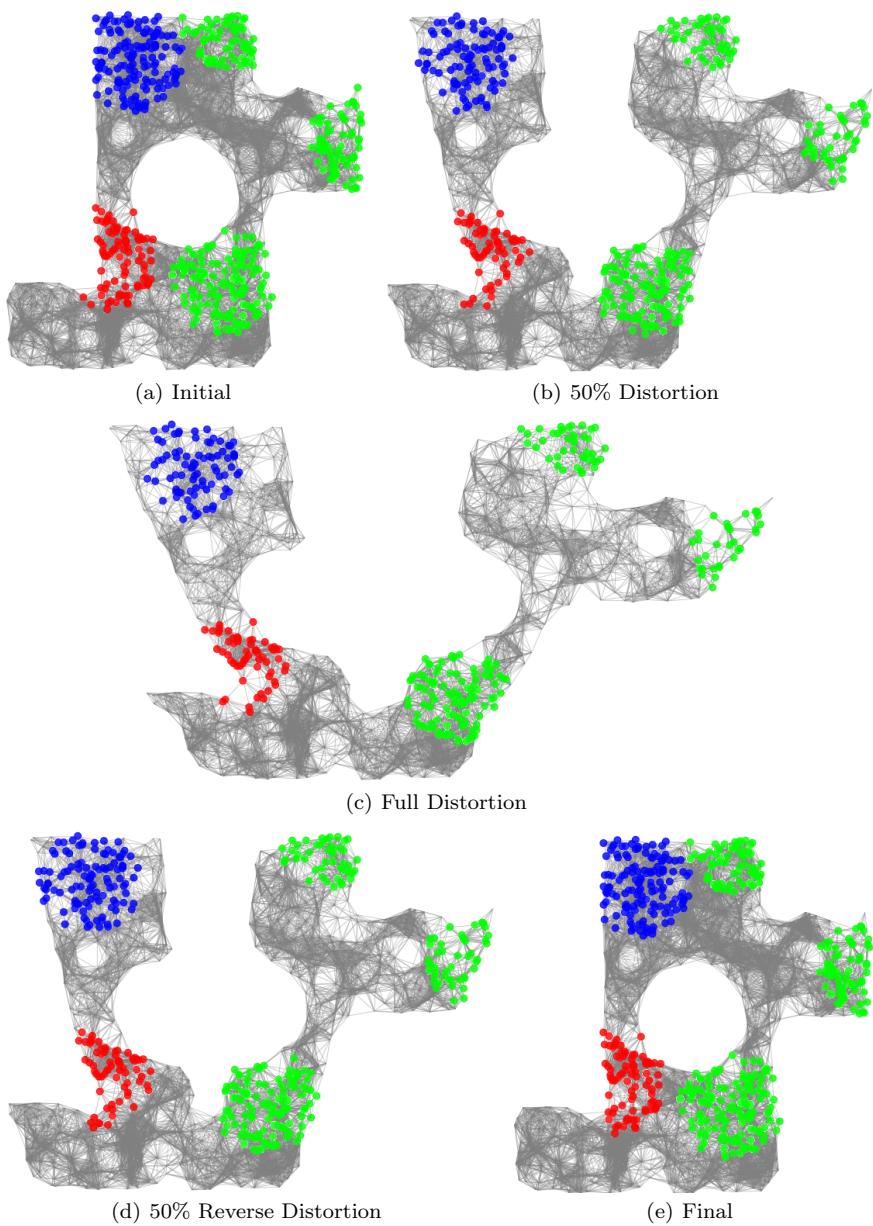


Fig. 24 Polka dot program executing on a complex shape under splitting distortion