National Centre for Computer Animation

Sketch-based Skeleton-driven 2D Animation and Motion Capture

Junjun Pan, Jian J Zhang

National Centre for Computer Animation
Media School
Bournemouth University

Outline

- Research background
- Objectives
- Framework and overview
- Contributions
- Algorithms and results
- Conclusion

Research background

- Traditional cartoon production is a laborious and time-consuming process. Animator drawing a single frame of character needs couple of hours.

Video 1 (Traditional cartoon drawing)

- Up until today, most professional 2D cartoon studios still produce huge amounts of animation (including key-frames and in-betweens) manually.

Research objectives

Motivated by the sketch-based animation techniques and recent progress in 2D shape deformation, our research is aimed at investigating and designing an efficient and easy-to-use technique for quick articulated cartoon production. And a functional system is expected to be developed to cope with the practical requirements in 2D animation.

Framework

- Part 1: 2D character animation generation by sketching skeleton

- Part 2: Motion capture and retargeting

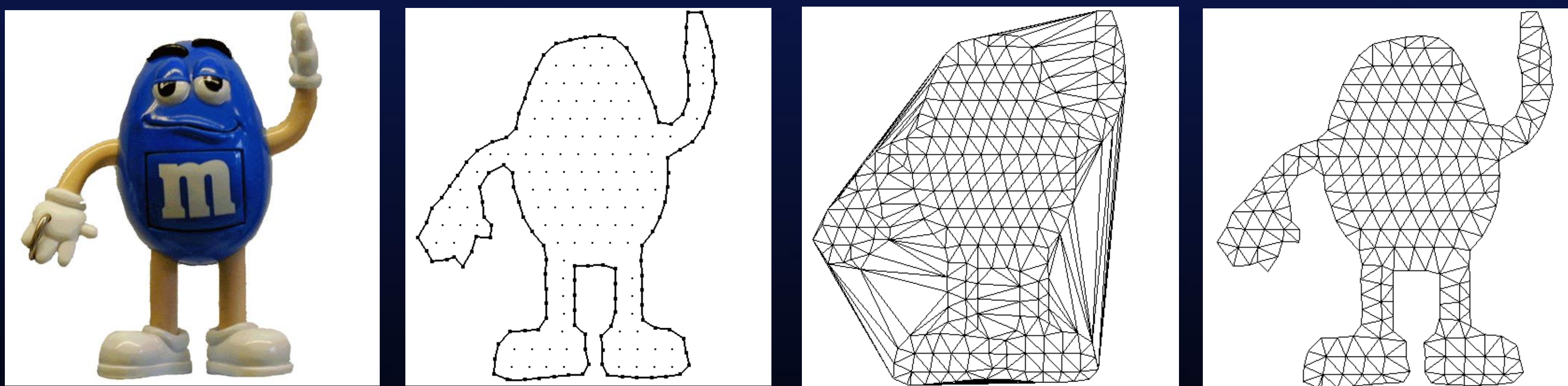
Contributions

1. A sketch-based skeleton-driven 2D animation technique is presented.
2. To handle 2D shape deformation, a *variable-length needle model* is developed and the *skeleton driven + nonlinear least squares optimization* algorithm is introduced.
3. A straightforward skeleton-based 2D motion capture technique is presented.

Sketch-based skeleton-driven 2D animation

1. Silhouette detection and triangulation
2. Skeletonization and decomposition
3. 2D shape deformation
4. Depth adjustment and fine tuning
5. Key-frame animation

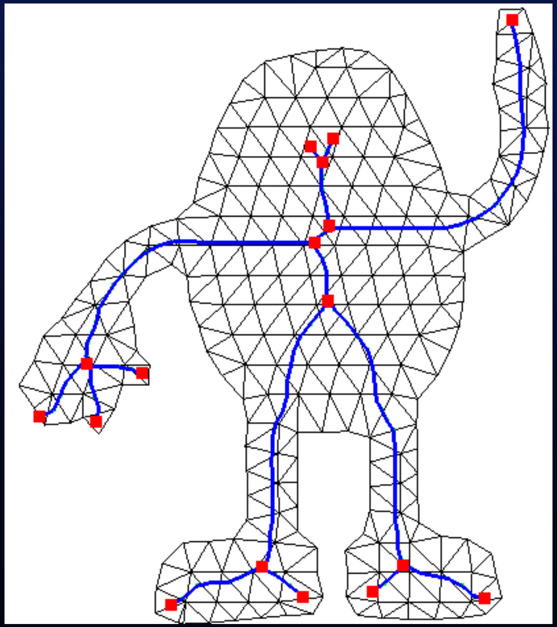
Silhouette detection and triangulation



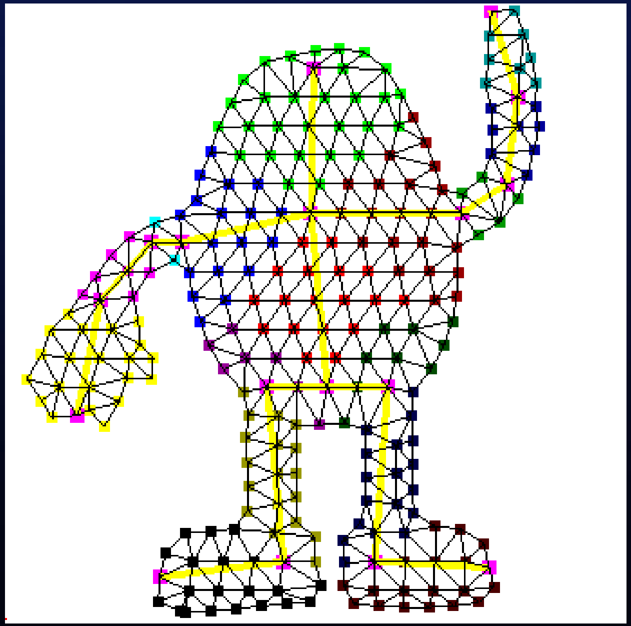
(a) (b) (c) (d)

Experimental results of a cartoon character in silhouette detection and triangulation. (a) Original template figure, (b) Silhouette detection and discrete sampling, (c) Standard Delaunay Triangulation, (d) Constrained Delaunay Triangulation

Skeletonization and decomposition



(a)



(b)

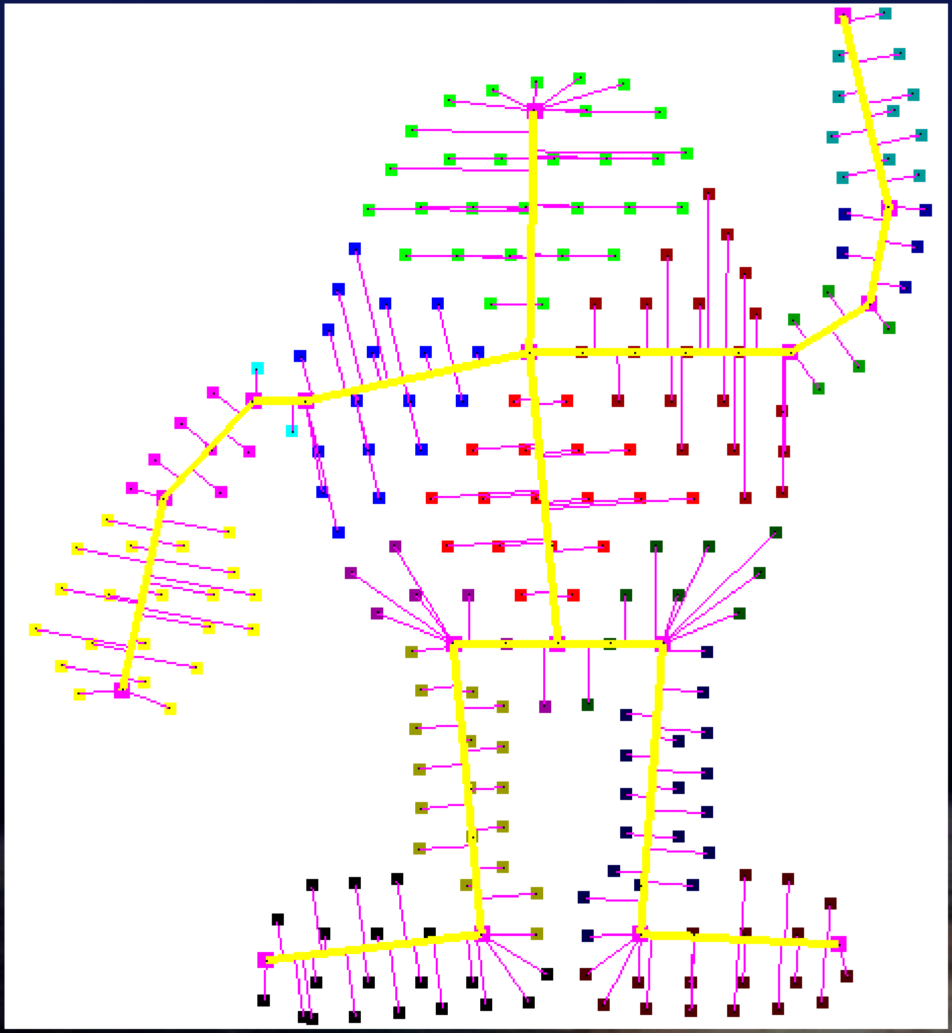
The result of skeletonization and decomposition. (a) Curve skeleton, (b) Decomposition result with skeleton

2D shape deformation

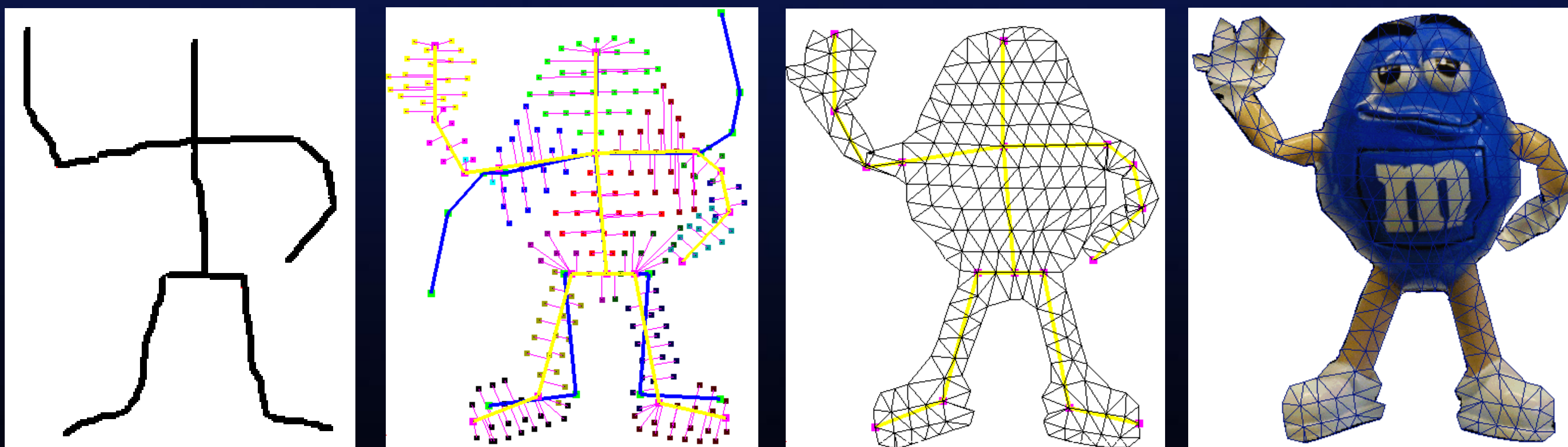
1. Variable-Length Needles Model

2. “Skeleton driven + Nonlinear Least Squares Optimization” Deformation Algorithm

Variable-length needles model



Stage one: skeleton driven deformation



(a) (b) (c) (d)

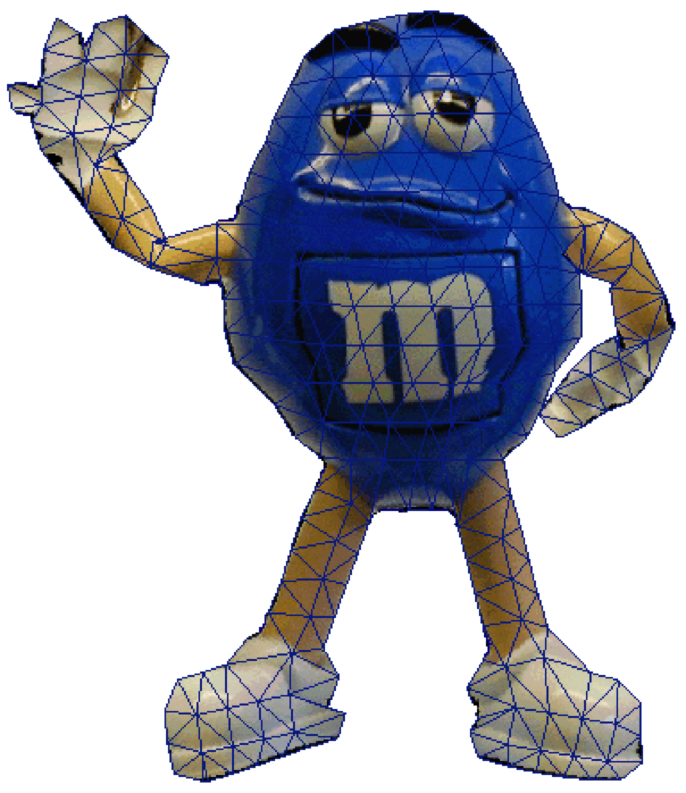
The deformation of a cartoon character with our algorithm. (a) Sketch skeleton inputted by hand drawing, (b) Deformed character displayed as “variable-length needles” model, (c) Deformed skeleton and character in mesh after Stage one, (d) Deformed character after Stage one

Stage two: nonlinear deformation in joints area

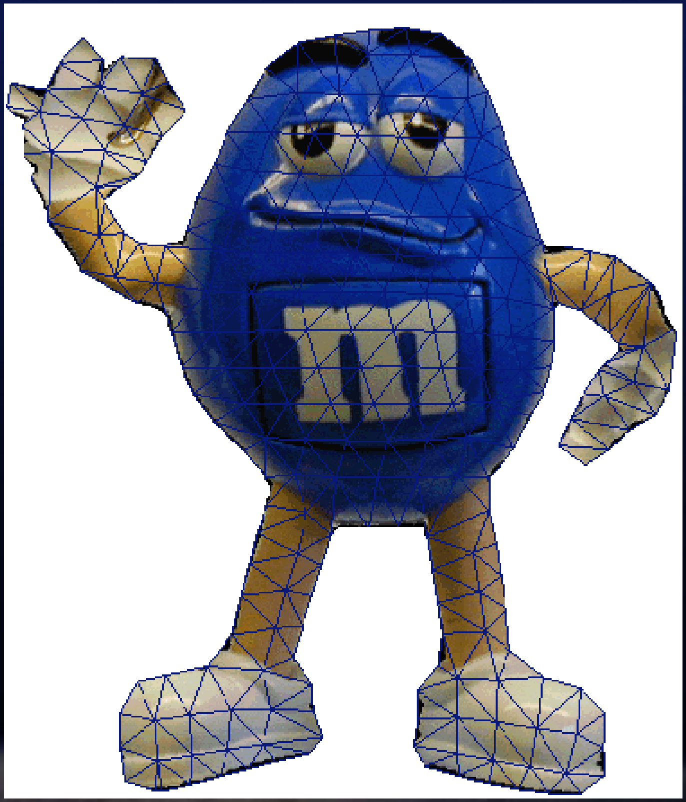
$$w_1 \| \mathbf{T}\mathbf{V}_{\mathbf{s}'} - \mathbf{T}\tilde{\mathbf{V}}_{\mathbf{s}'} \|^2 + w_2 \| \mathbf{H}\mathbf{V}_{\mathbf{p}} - \mathbf{H}\tilde{\mathbf{V}}_{\mathbf{p}} \|^2$$

1. RSI Laplacian coordinates (They preserve the local details of the figure boundary and is used to minimize silhouette distortion in joints area)
2. Edge lengths (They preserve the local area and is used to minimize the interior shape distortion in joints area)

Stage two: nonlinear deformation in joints area



(a)

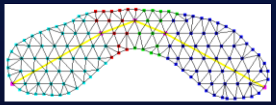


(b)

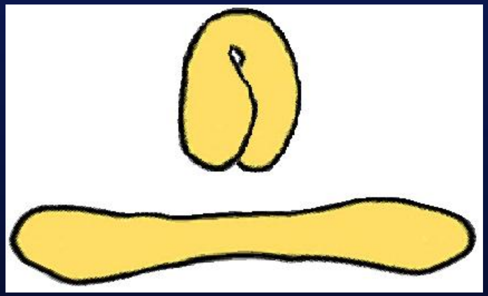
(a) The character after skeleton driven deformation, (c) The character after the nonlinear deformation in joints area

Experimental comparison

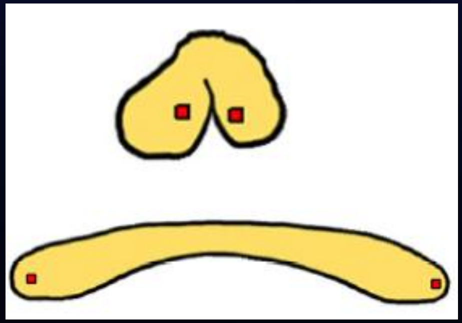
(a)



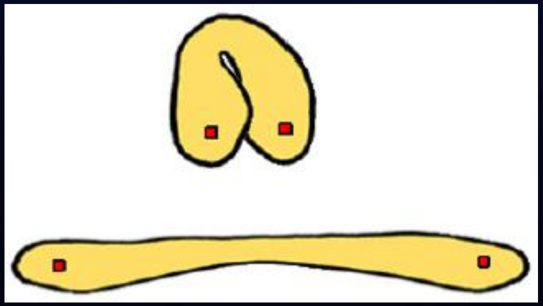
(b)



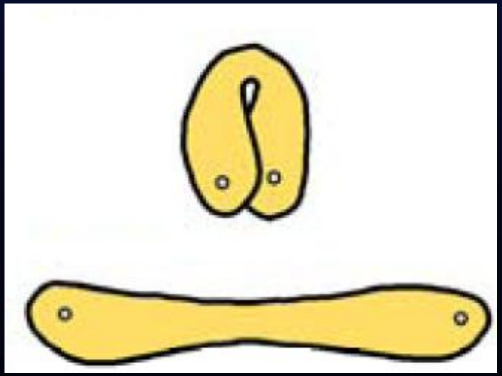
(c)



(d)



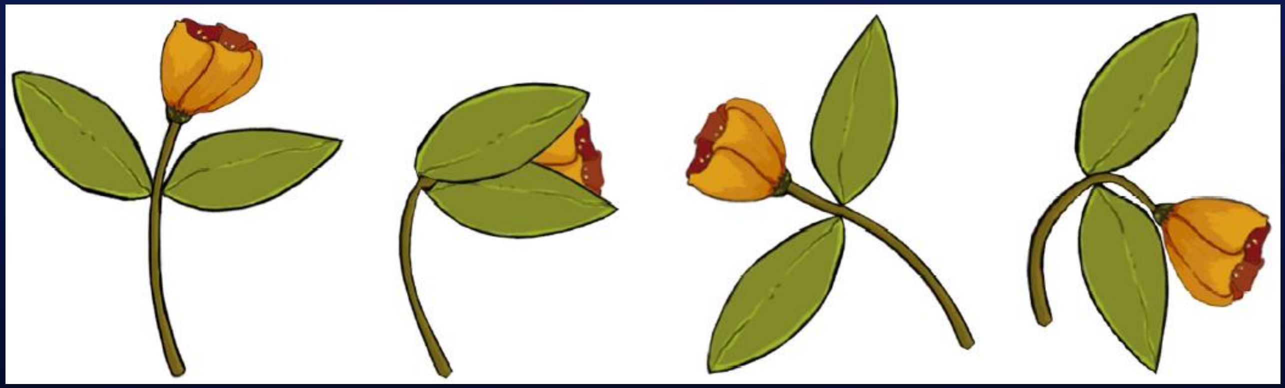
(e)

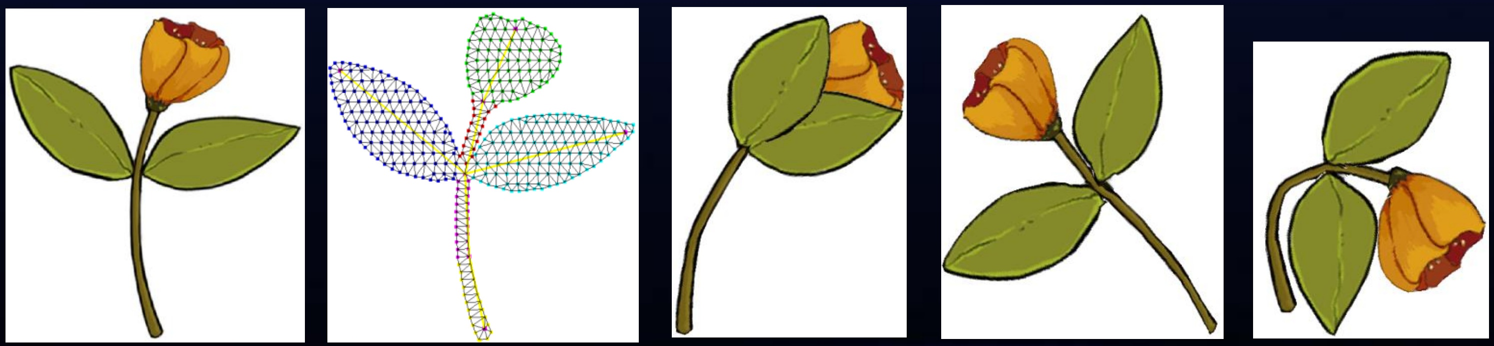


(f)

Comparison between our algorithm and two important 2D shape approaches. (a) Original object, (b) Decomposition result with skeleton, (c) Deformation result with our algorithm, (d) Result in [Igarashi et al. 2005], (e) Result in [Weng et al. 2006], (f) Target result.

Experimental comparison





Two groups of flowers deformed by our algorithm and the method in [Weng et al. 2006]. (a) Deformation results in [Weng et al. 2006], (b) Deformation results with our algorithm. (From left to right is original template figure, decomposition result with skeleton, deformed figures)

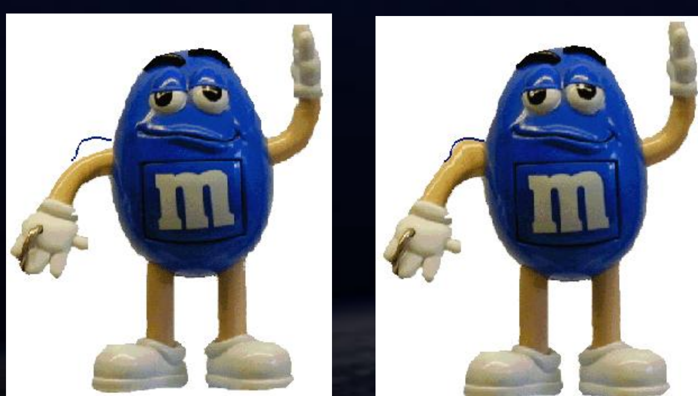
Experimental comparison

Table 1 Comparison of data statistics and timing

The approach in [Weng et al. 2006]		Our deformation algorithm	
Cartoon model	flower	Cartoon model	flower
Boundary vertexes	114	Total vertexes	382
Interior vertexes	256	Joint vertexes	27
Precomputing time	22ms	Precomputing time	9ms
Iteration time	0.589ms	Iteration time	0.143ms

Depth adjustment and fine tuning

(a)



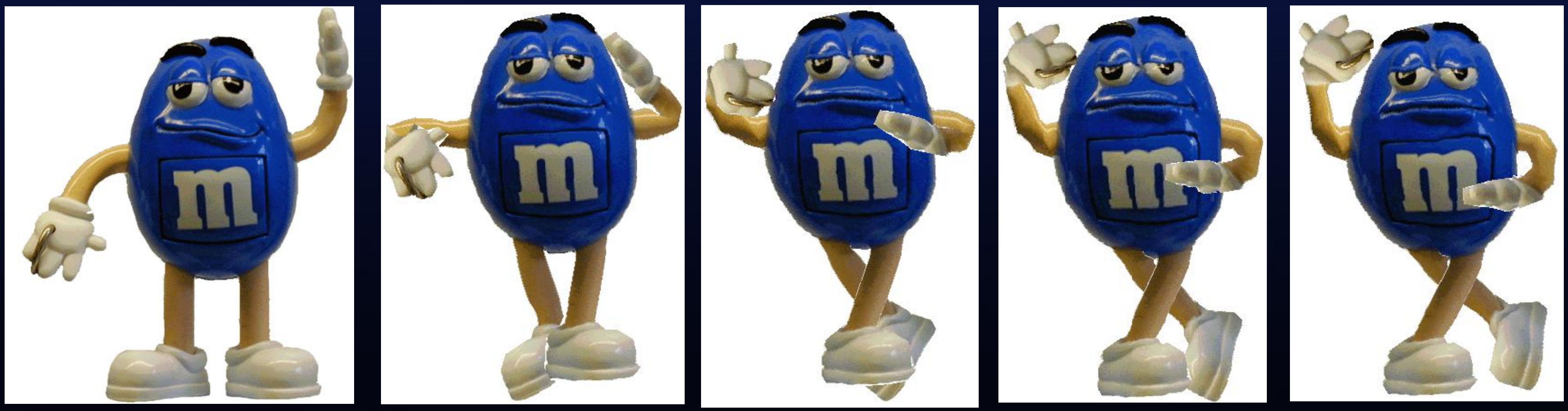
(b)

(c)

(a) Depth adjustment. (b) Sketch curve fine tuning, (c) Point dragging

In-betweens

$$\underset{t\in[0,1]}{f(t)} = \mathrm{slerp}[\, f_{start} \times (1-t) + f_{middle} \times t] + (f_{end} - f_{middle}) \times t$$



t = 0 | t = 0.25 | t = 0. 5 | t = 0.75 | t = 1

Five in-between figures in an example of key-frame animation.

Motion capture and retargeting

Initial setup for motion capture.

(a) Original character in the first frame and located joints, (Copyright: Disney)

(b) Target character and its decomposition results (Copyright: SEGA)

Tracking

$$\min \sum_{m=1}^{n} D_{mt}$$

s. t. $$D_{mt} = w_\alpha D_{c,mt} + w_\beta D_{g,mt}$$

$$D_{c,mt} = F(\mathbf{c}_{mt}, \mathbf{c}_{mt-1})$$

$$D_{g,mt} = (x_{mt} - \bar{x}_{mt})^2 + (y_{mt} - \bar{y}_{mt})^2$$

Retargeting

$$\Delta l_{m,t} = l_{m,t} / l_{m,t-1}, \Delta\alpha_{m,t} = \alpha_{m,t} - \alpha_{m,t-1} \qquad l'_{m,t} = l'_{m,t-1}\Delta l_{m,t}, \alpha'_{m,t} = \alpha'_{m,t-1} + \Delta\alpha_{m,t}$$

frame1 frame6 frame12 frame18

Conclusions

- Compared with the conventional practice where all key-frames are hand-produced, our sketch-based method requires much less user input without depriving the animator’s control of the artistic quality. It is faster and less labour-intensive to create 2D animation.
- Our 2D motion capture technique can be applied to various types of moving images, including 2D cartoon animation, videos and rendered image sequences. This facilitates the reuse of the characteristics of the motion contained in existing moving images, making the process of cartoon generation easy for artists and novices alike.

Video 2 (Demo of my work)

Thank you