# The MorphoxX Project

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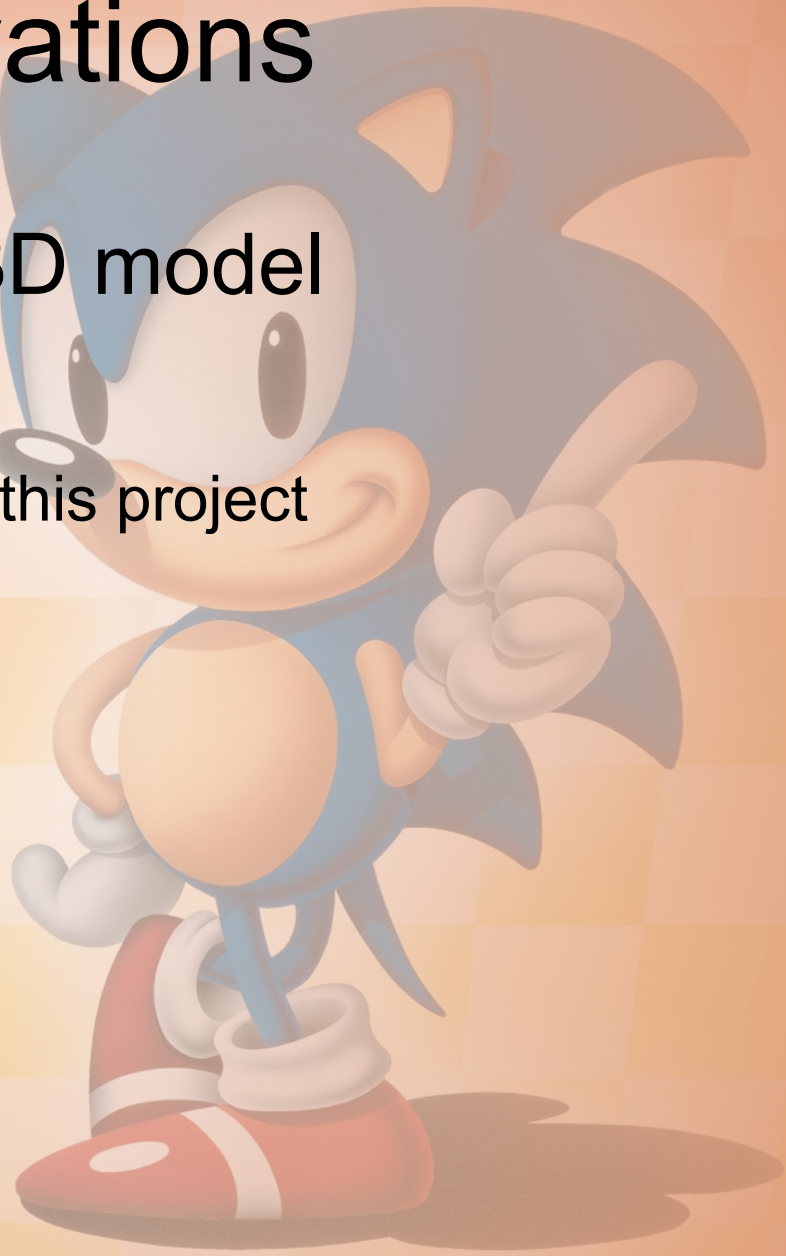
SONIC TEAM SEGA

# Goal and motivations

- Goal: tool to deform quickly 3D model
  - ➔ Cage-based methods
    - ➔ 3 coordinate systems studied in this project
- Let's do a quick demo!
- Applications:
  - Animated movies
  - Video games

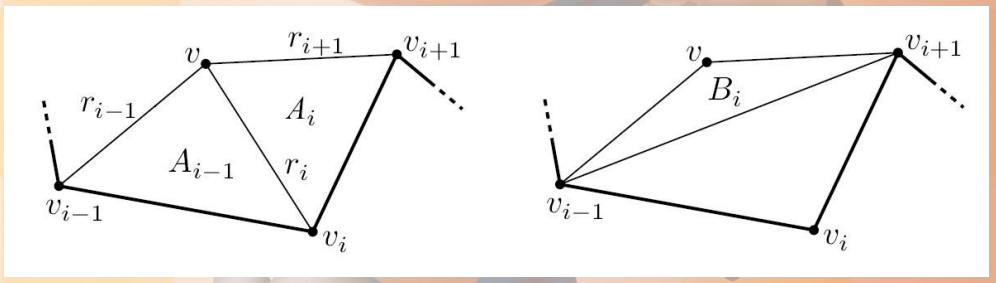


# Mean Value Coordinates

- Generalized barycentric coordinates.

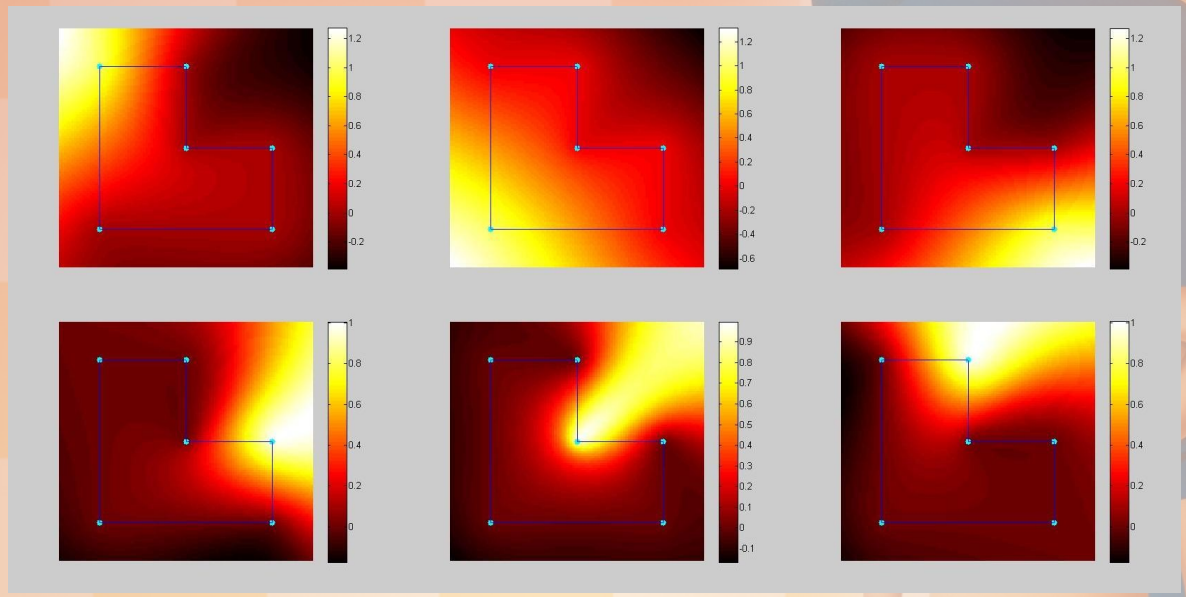
$$\{w_i : \mathbb{R}^2 \to \mathbb{R}, i \in [\![1,n]\!]\} \; so\; that \sum_{i=1}^{n} w_i(v)(v_i - v) = 0$$

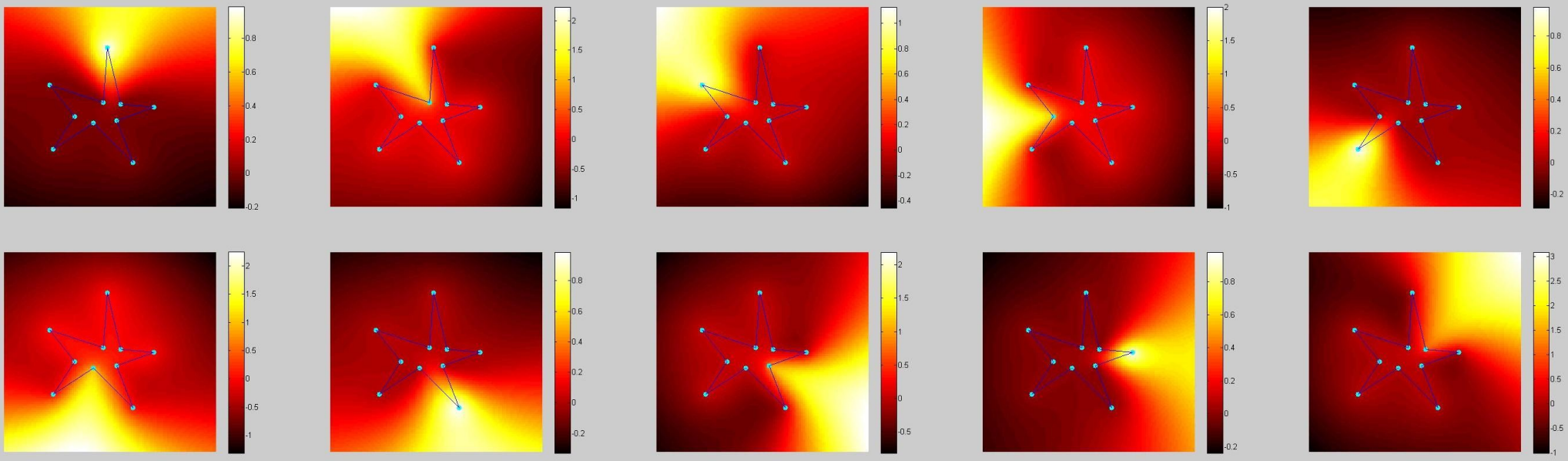
$$w_i = \frac{r_{i-1}A_i - r_i B_i + r_{i+1}A_{i-1}}{A_{i-1}A_i}$$




- Coordinates are normalized in the end

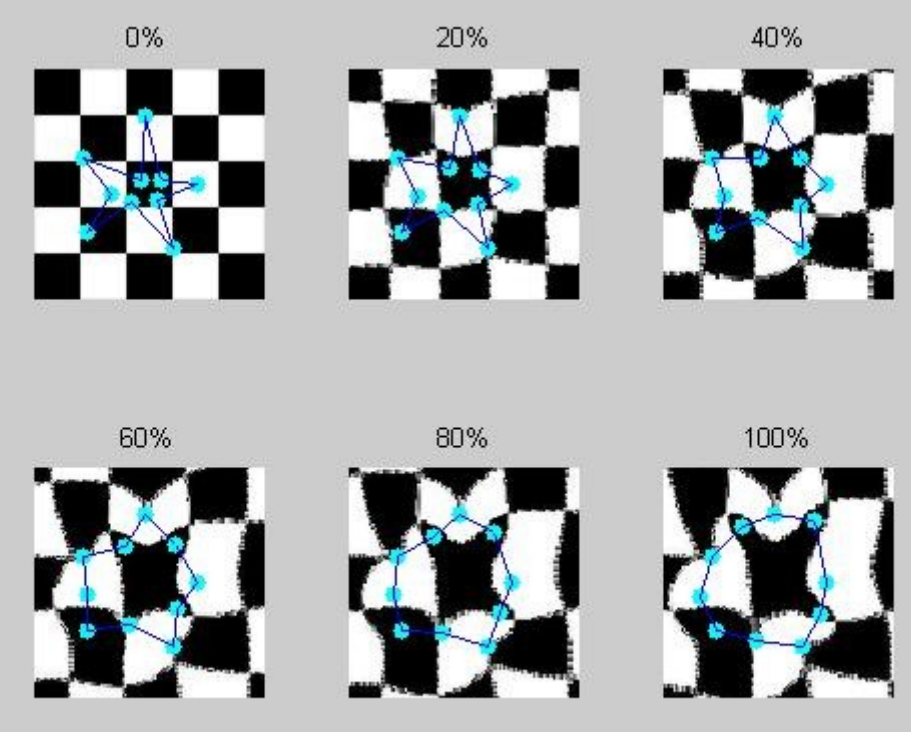
# Mean Value Coordinates

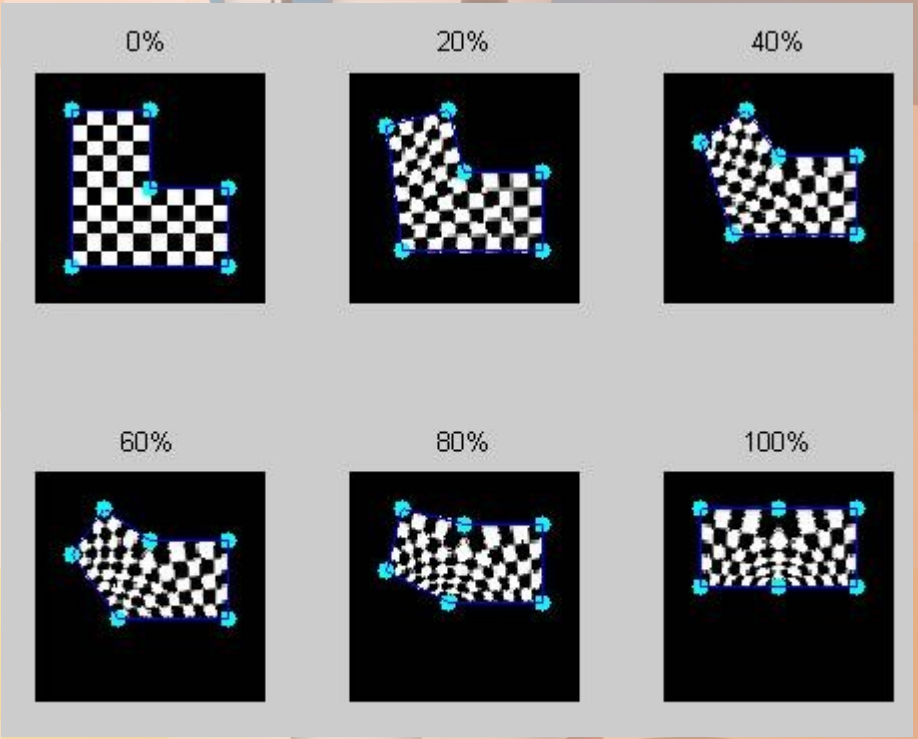




# Mean Value Coordinates

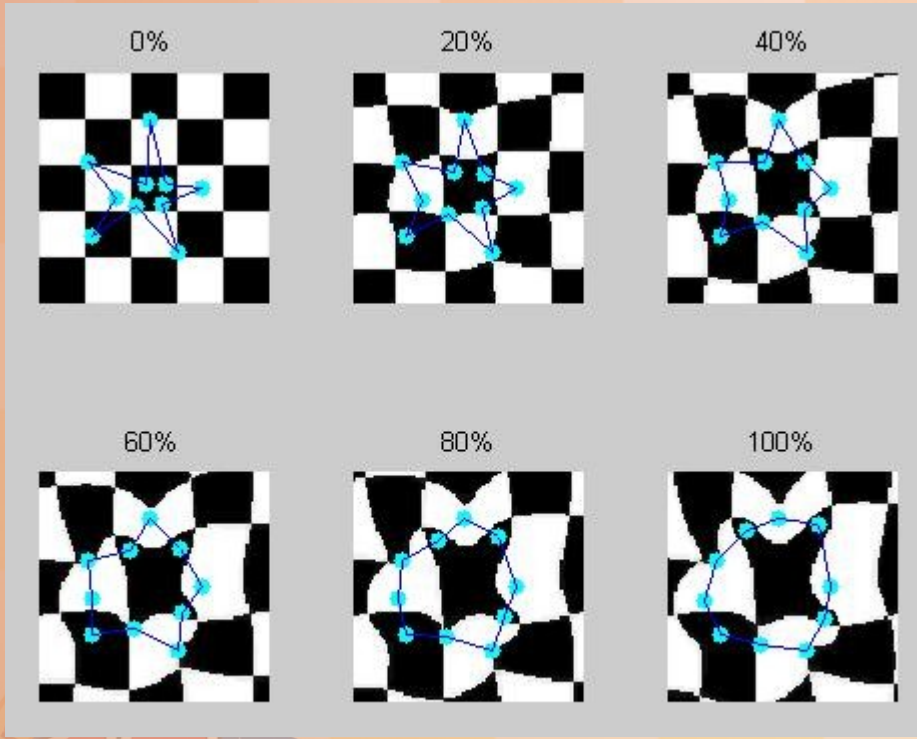
- Progressive deformations:

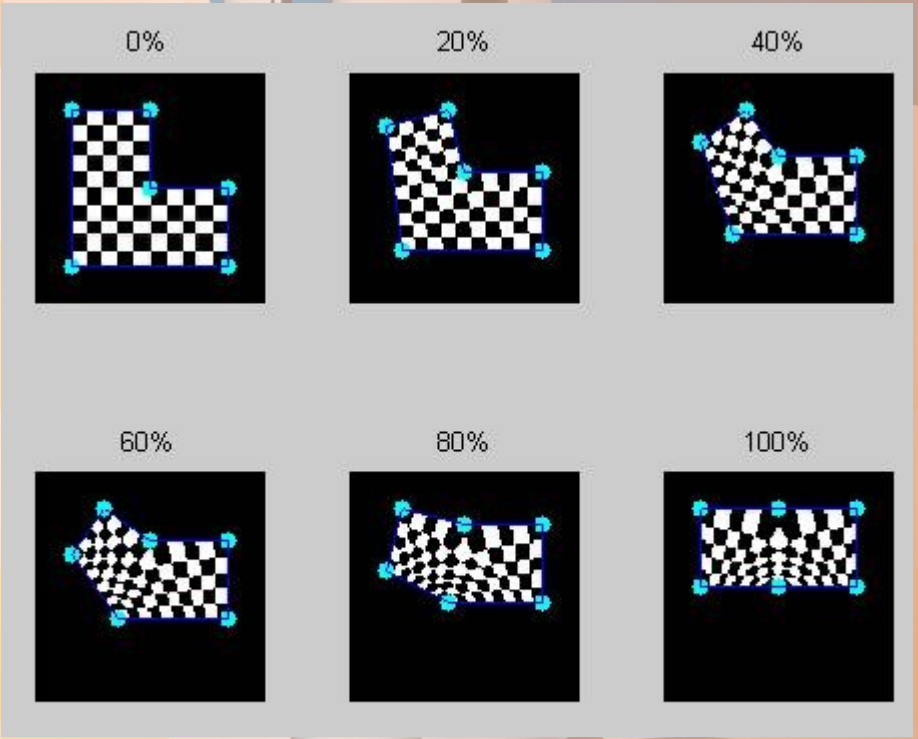


# Mean Value Coordinates

- Using nearest pixel instead of interpolation:

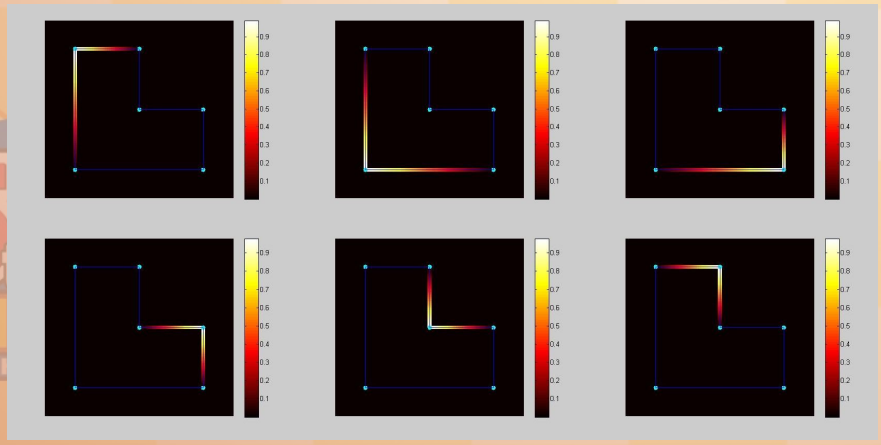


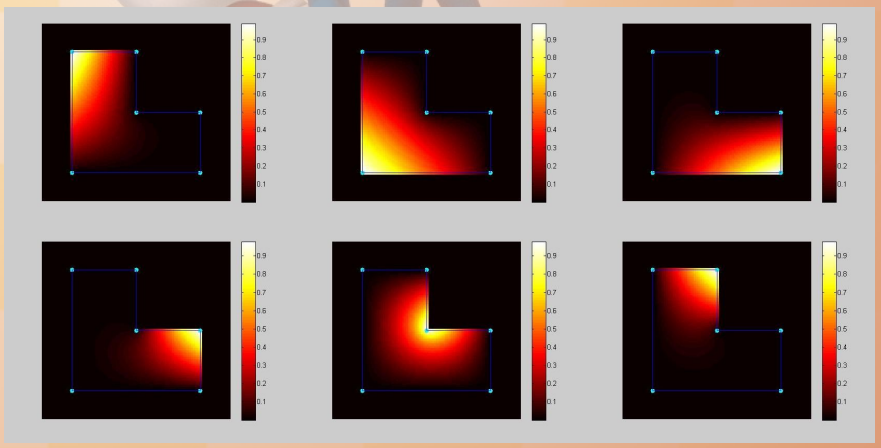



# Mean Value Coordinates

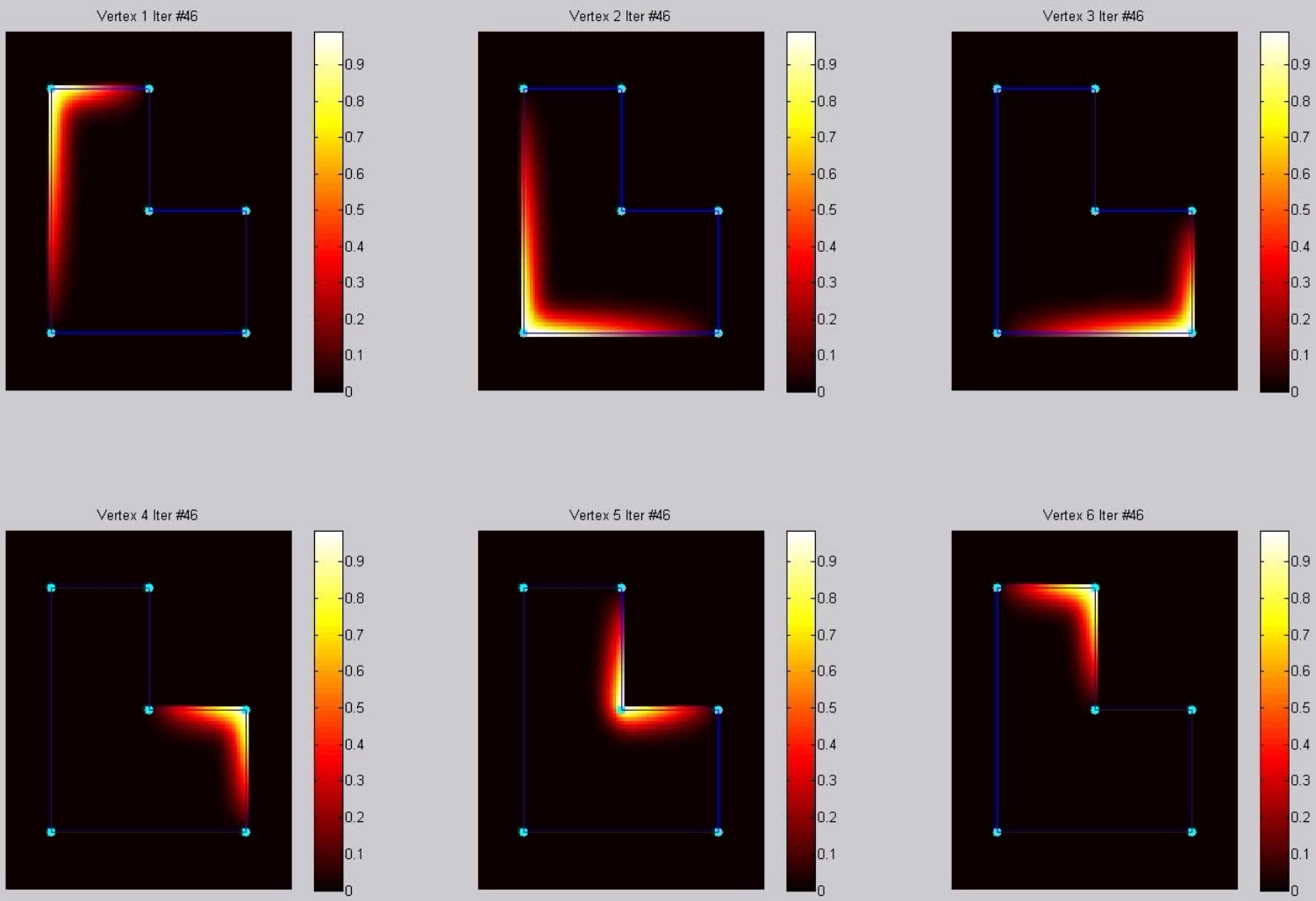
# Harmonic Coordinates

- Defined on the interior of the cage
- $\forall i \in [\![1,n]\!],\ \forall v \in \mathring{C},\ \Delta w_i(v) = 0$
- Creation of a mask
- Initialization on the boundaries
- Propagation in the interior via 4c-averaging



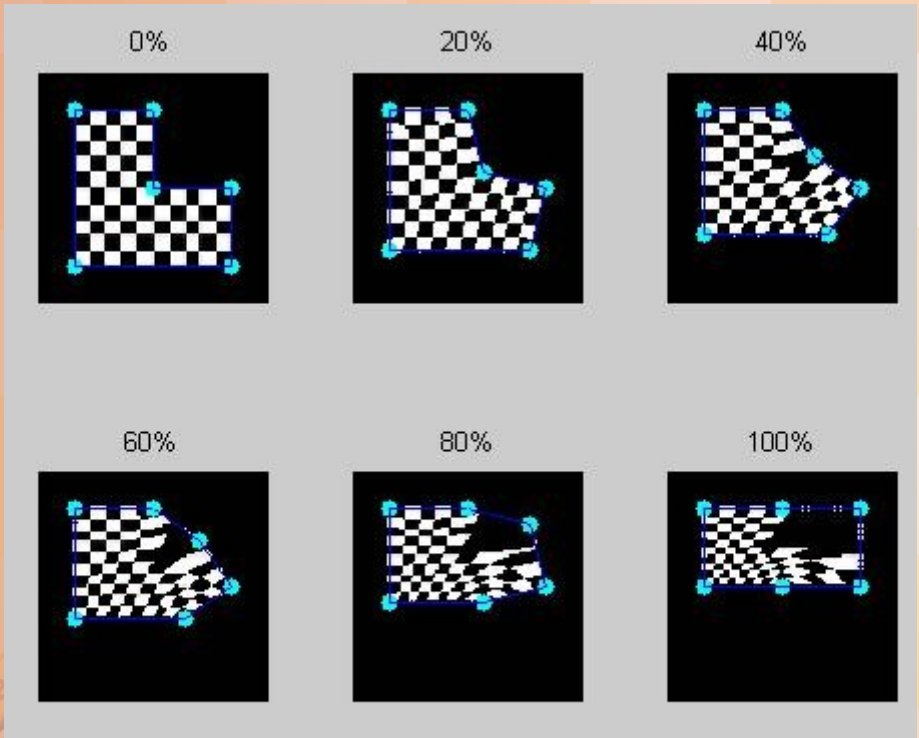


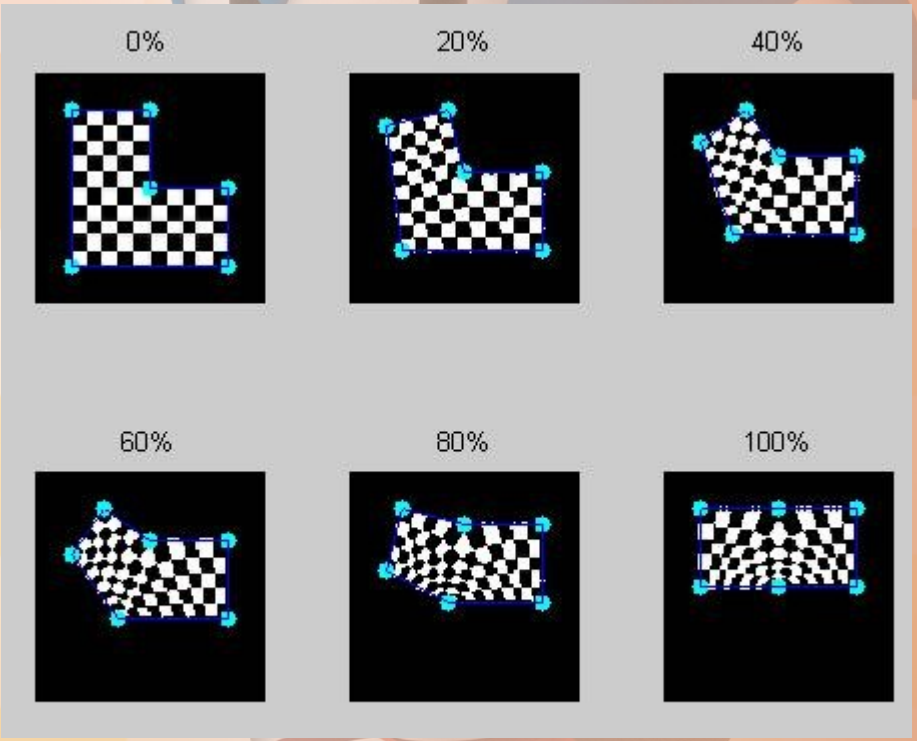
# Harmonic Coordinates



# Harmonic Coordinates

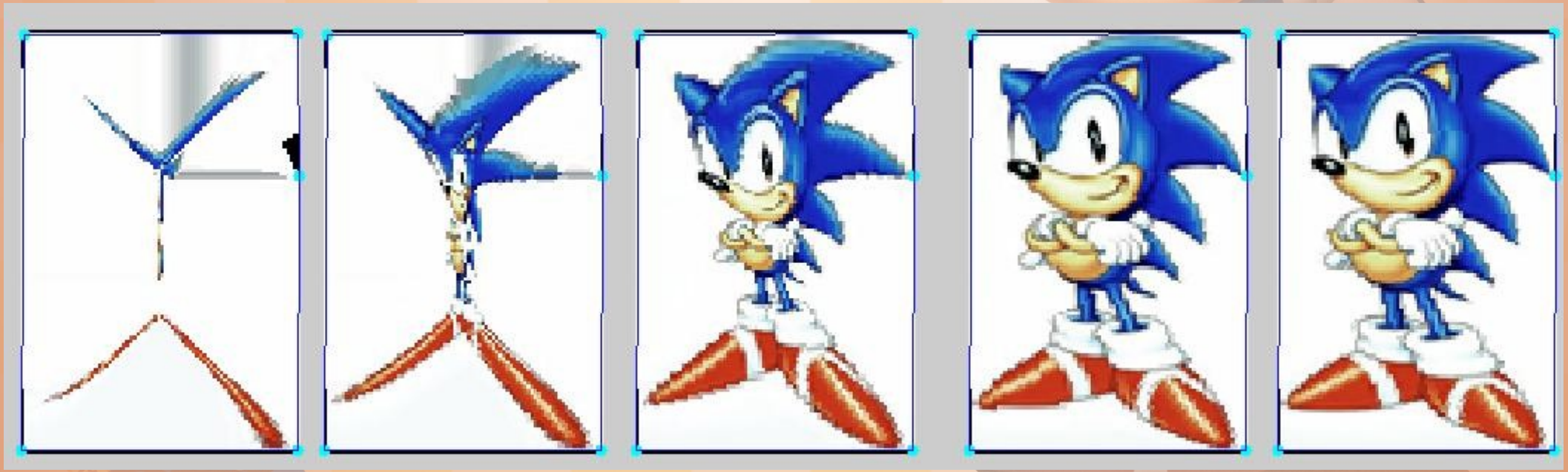
- Progressive deformations:



# Harmonic Coordinates

- Require enough iterations
  - Examples with 100, 500, 2000, 5000, and 20000 iterations:



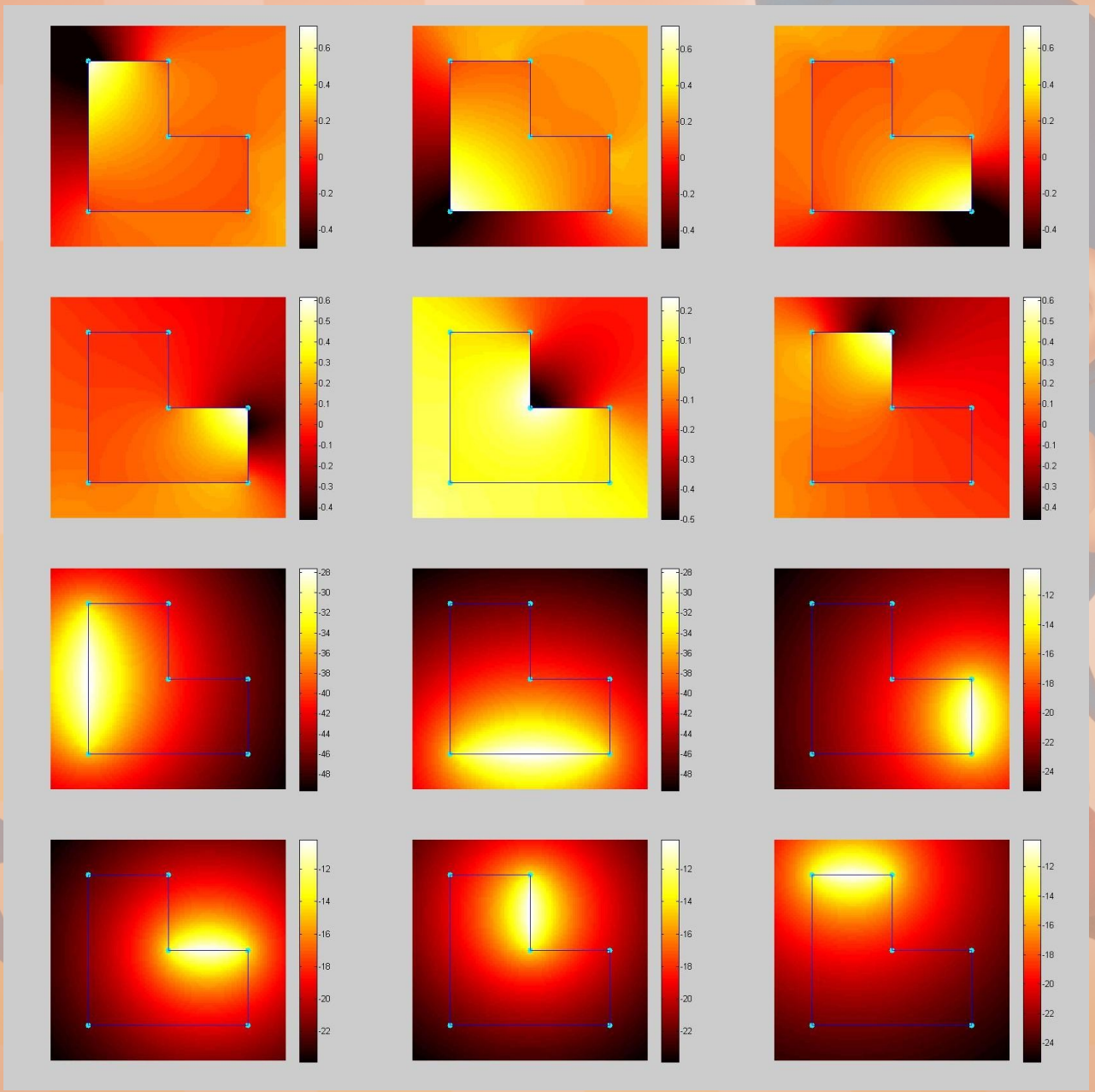
# Harmonic Coordinates

- Sonic 300*450, 29 vertices, 25000 iterations
  - Born after 21 hours of computation on a Dell XPS Gen 2 with proc Intel Pentium M 2.13 GHz... but he is cute, isn't he?

# Green Coordinates

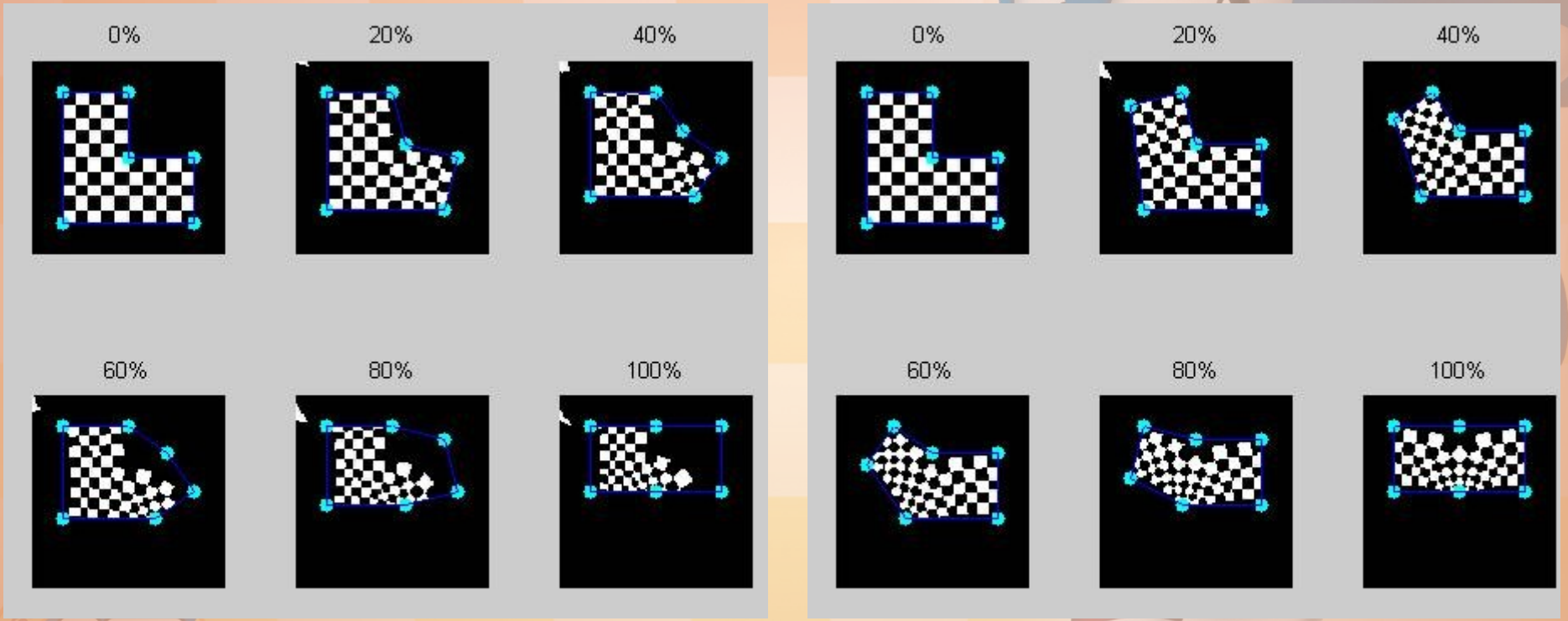
- Added terms based on face elements to have coordinates respecting the cage's faces' orientations
- $$v = \sum_{vertices} \phi_i(v) v_i + \sum_{edges} \psi_i(v) n(t_i)$$
- $$v' = \sum_{vertices} \phi_i(v) v_i' + \sum_{edges} \psi_i(v) s_i n(t_i') \quad with\ s_i = \frac{\|t_i'\|}{\|t_i\|}$$
- TRICK: Normalisation of the vertex-based terms (to be origin invariant: previous formulation: affine space ↔ vectorial space)

# Green Coordinates



# Green Coordinates

- Progressive deformations:

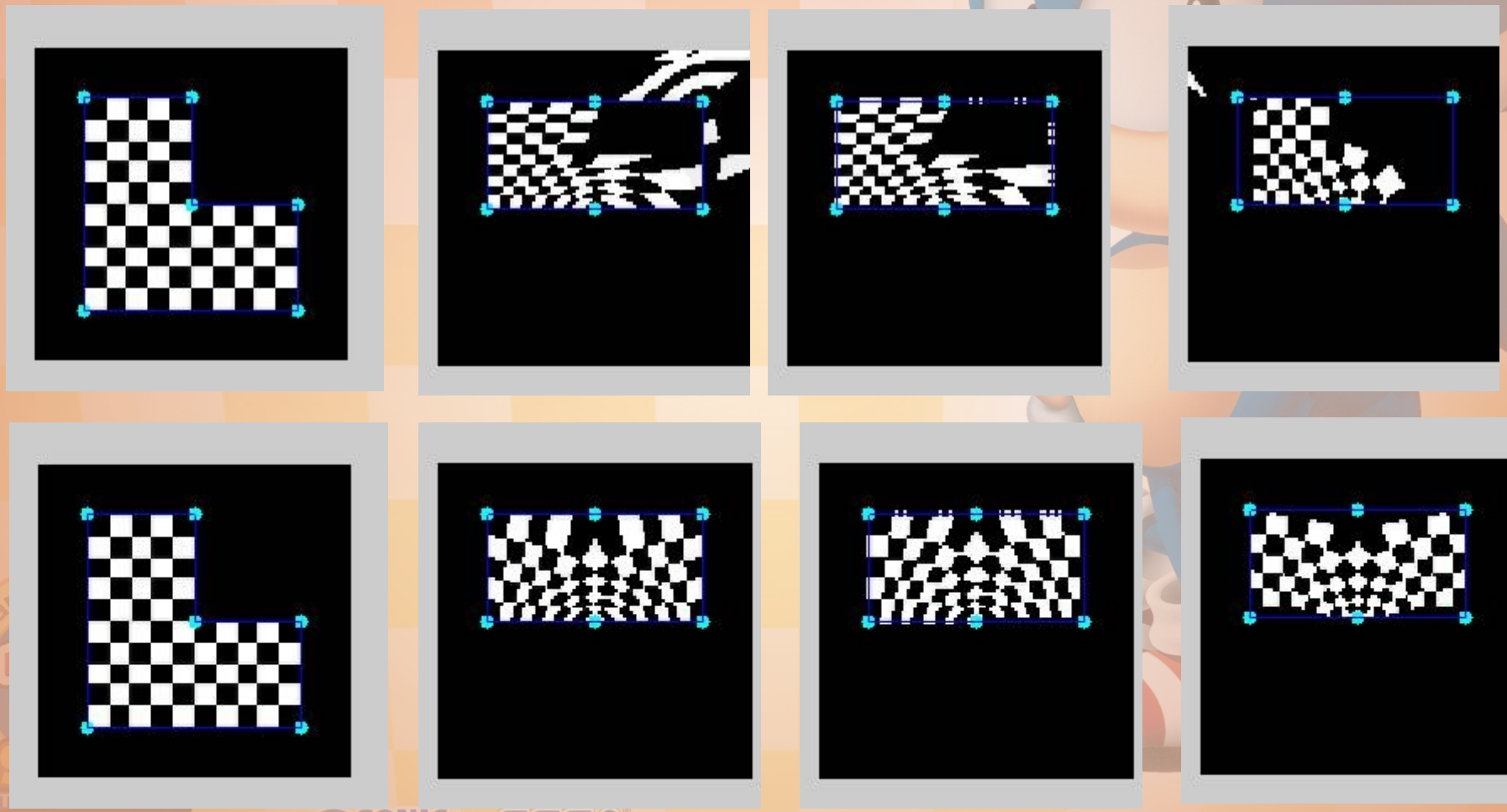


# Green Coordinates

- Note the flexibility to allow the model to step out of the cage (continuity outside not implemented)

# Comparison

- Original – MVC – HC – GC:



# Comparison

- Initial – MVC – HC – GC:

# Conclusion

| | MVC | HC | GC |
|---|---|---|---|
| Computing time | ★★★ | ★ | ★★ |
| Simplicity | ★★★ | ★★★ | ★ |
| Flexibility | No | No | Yes |
| Defined everywhere | Yes | No | Yes |
| Partial deformations | ★ | No | ★★★ |

- Source code available at http://code.google.com/p/morphoxx