

# MagicToon: A 2D-to-3D Creative Cartoon Modeling System with Mobile AR

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# Children Like Coloring





# Existing AR Coloring Apps



Figure: A screenshot of the AR coloring app *Chromville* on iOS and Android



# Existing AR Coloring Apps

The 2D  
templates  
are ready-  
made



Figure: A screenshot of the Disney research  
(Magnenat et al. 2015)

The 3D  
models are  
manually  
modeled in  
advance



# The Demand for 3D Models is Growing

- But modeling is hard for novice users
  - Professional modeling systems are complicated

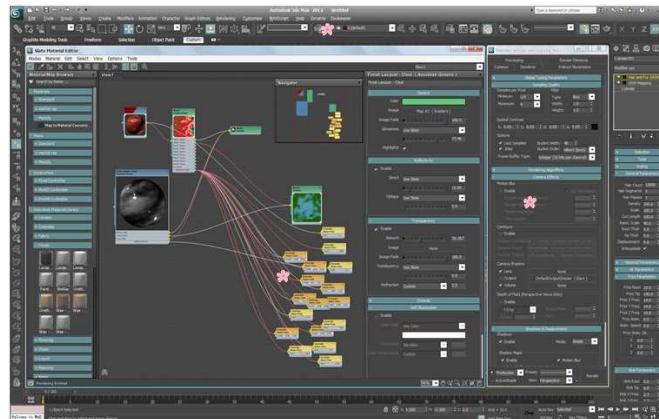


Figure: A screenshot of Maya

Too complicated  
interface



# Sketch-based Modeling Systems

- *Teddy* - Igarashi et al. 1999
- *ShapeShop* - Schmidt et al. 2005
- *FiberMesh* - Nealen et al. 2007
  - Simplifies the traditional modeling pipeline
  - Feel frustrated easily with the change of views
  - Losing physical enjoyment

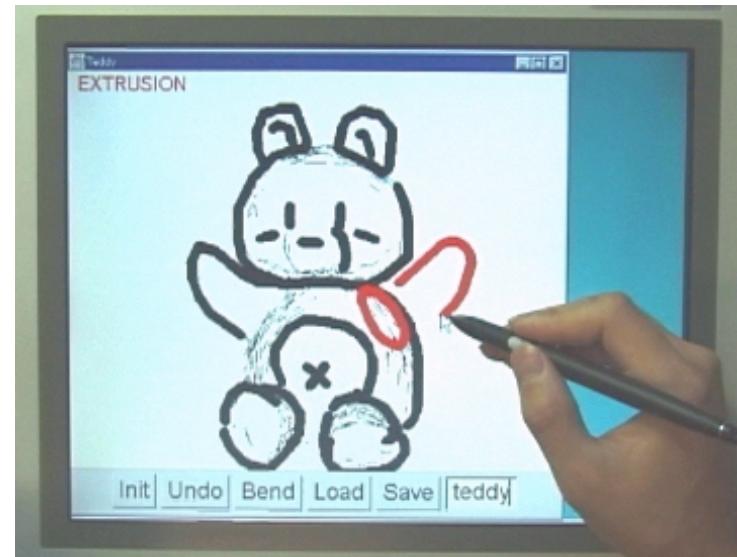


Figure: A screenshot of *Teddy* (Igarashi et al. 1999)



# Authoring Models in AR

- Modeling by using CAD tools
  - ARpm - Fiala et al. 2005
  - Air Modeling - Arroyave-Tobón et al. 2015
- Construct AR scenes by simple solid models
  - Bergig et al. 2009
- Sketch to author models created in advance
  - Sketchaser - Hagbi et al. 2010
  - E.S.DeLima et al. 2014

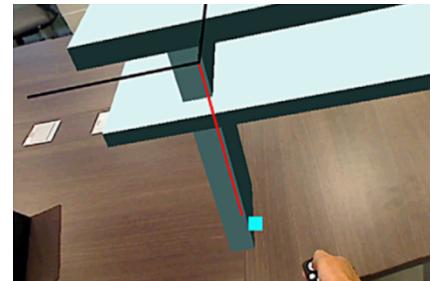


Figure: Air Modeling  
(Arroyave-Tobón et al. 2015)



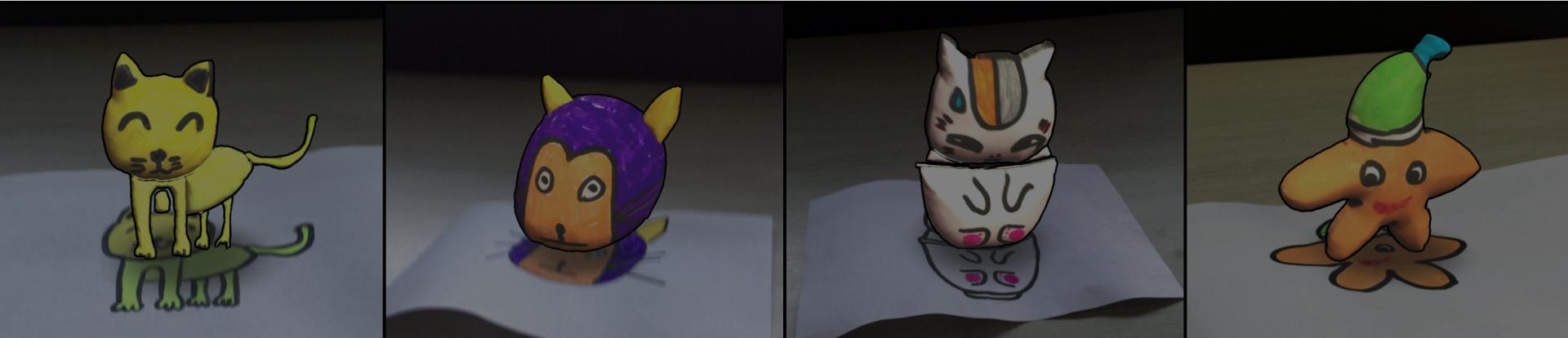
Figure: Air Modeling  
(Arroyave-Tobón et al. 2015)



# Our Contributions

1. Present an automatic 2D-to-3D model creator on mobile devices
  - Convert 2D drawings into 3D cartoon models with AR enabled
2. Propose a creative modeling pipeline including a model creator and a model editor
  - Enable children to construct personalized AR scenes easily
3. Conduct a user study showing the comparison results among three cartoon systems

# WORKFLOW





# System Workflow

1. Sketch and color a cartoon drawing on real paper





# System Workflow

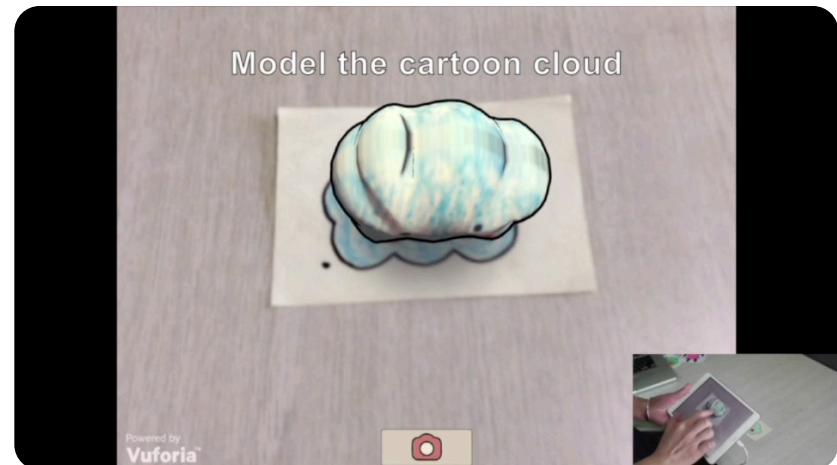
1. Sketch and color a cartoon drawing
2. Get a textured 3D model with mobile AR in one tap





# System Workflow

1. Sketch and color a cartoon drawing
2. Get a textured 3D model with mobile AR in one tap
3. Edit models in AR



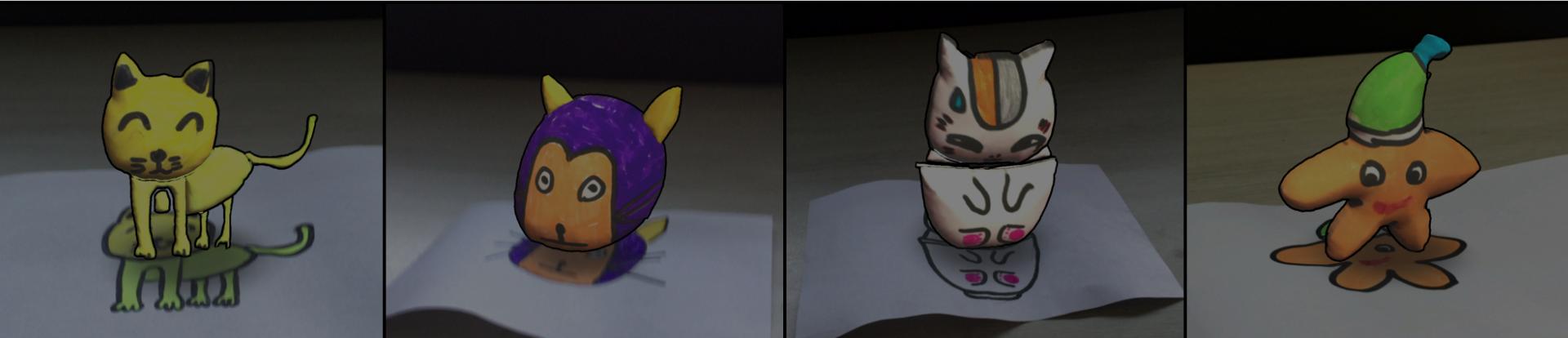


# System Workflow

1. Sketch and color a cartoon drawing
2. Get a textured 3D model with mobile AR in one tap
3. Edit models in AR
4. Compose an AR scene



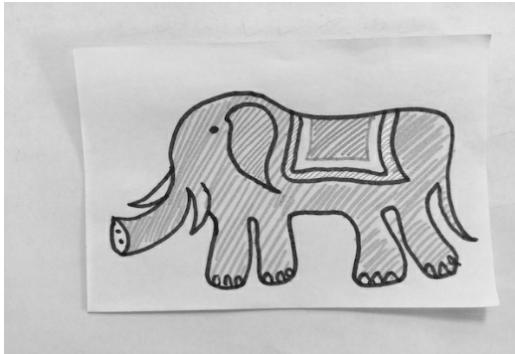
# MODEL CREATOR



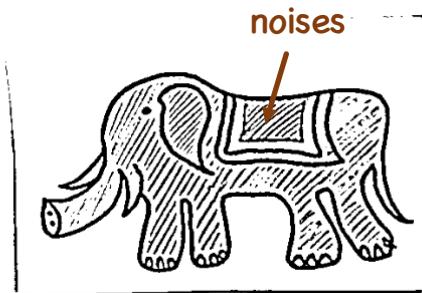


# The Model Creator

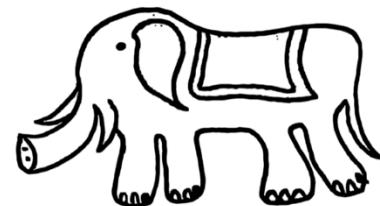
## Segmentation



(a) S channel of the input



(b) Initial outline map



(c) Final outline map

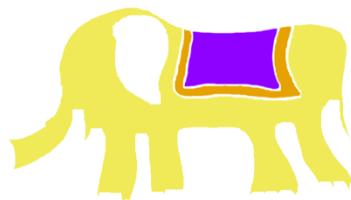


(d) Region maps

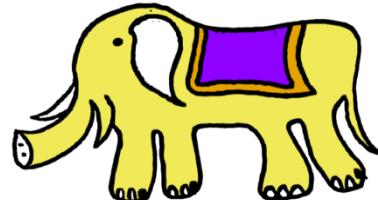


# The Model Creator

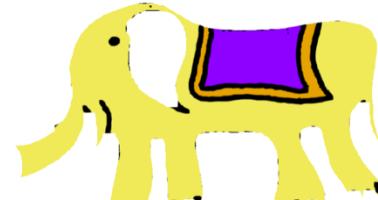
## Merging Regions



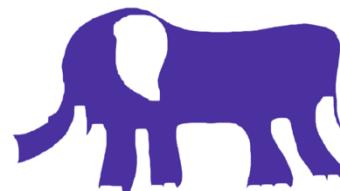
(a) Region maps being merged



(b) Combine with the outline map



(c) The result after erosion



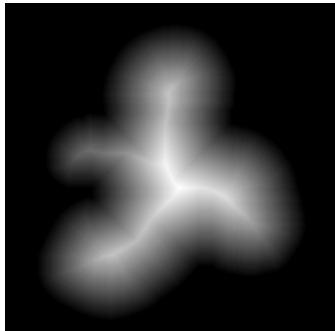
(d) The new region map

Erode using the outline width (thinning algorithm  
- Zhang & Suen, 1984)

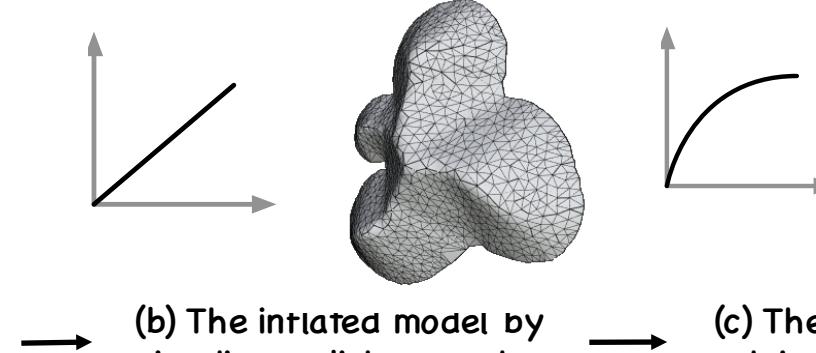


# The Model Creator

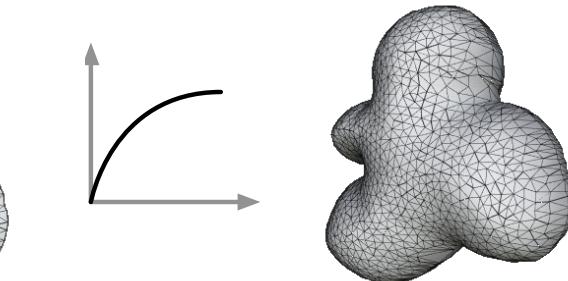
## Mesh Generation



(a) The distance map



(b) The inflated model by  
using linear distance values



(c) The smooth model by  
applying a circular mapping



(d) The new region map

NaturaSketch -  
Olsen et al. 2011



# The Model Creator

## Register to AR environments

Use Vuforia for real-time tracking



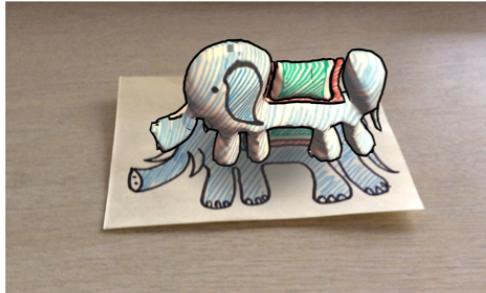
# MODEL EDITOR



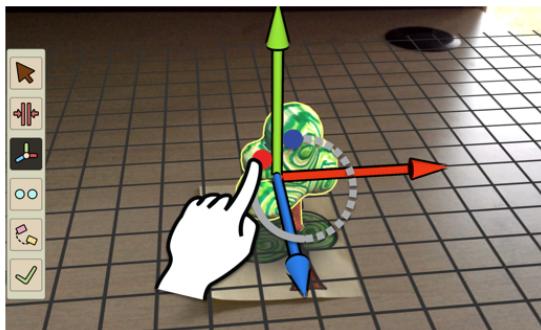


# The Model Editor

## Interaction



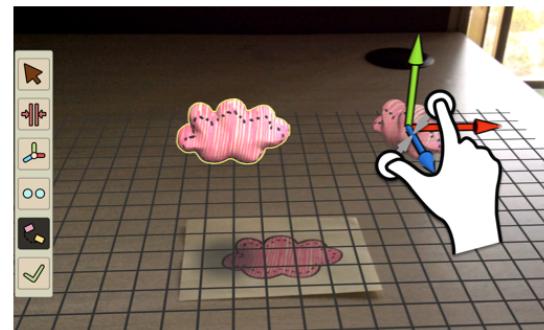
(a) Merge



(b) Affine transformation



(c) Copy



(d) Animation



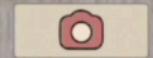
# The Model Editor

## Interaction: Merge

Model by just capturing an image



Powered by  
**Vuforia™**





# The Model Editor

## Interaction: Affine Transformation & Copy

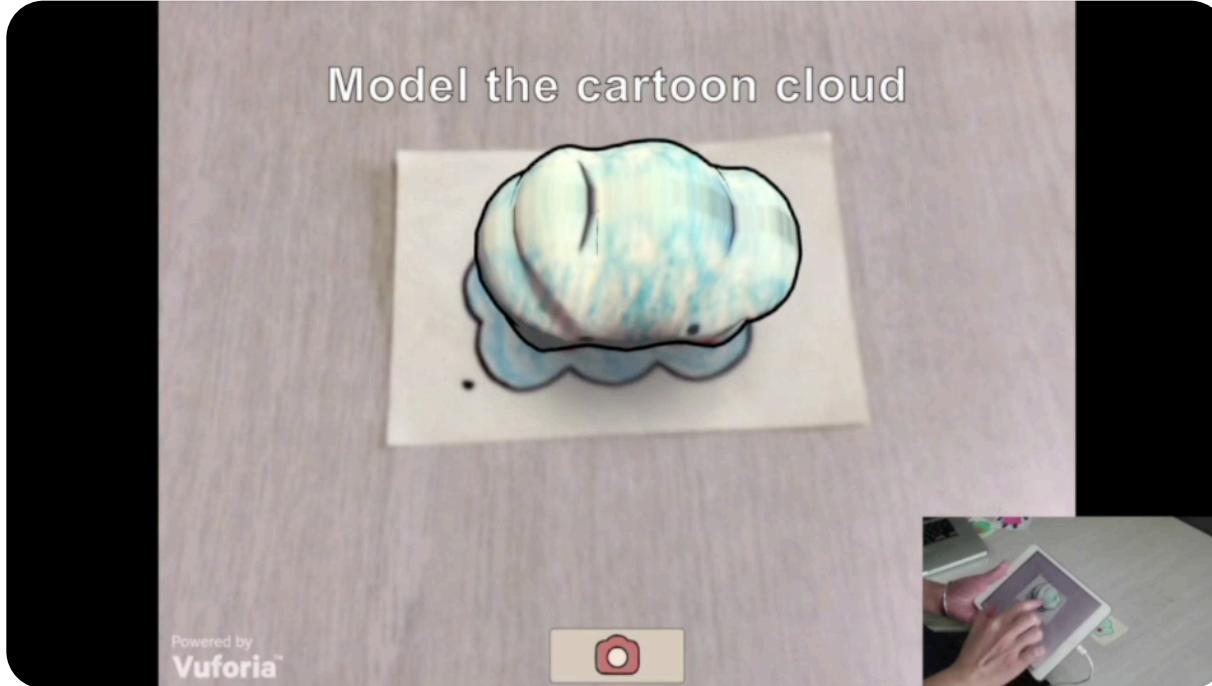


Powered by  
**Vuforia™**



# The Model Editor

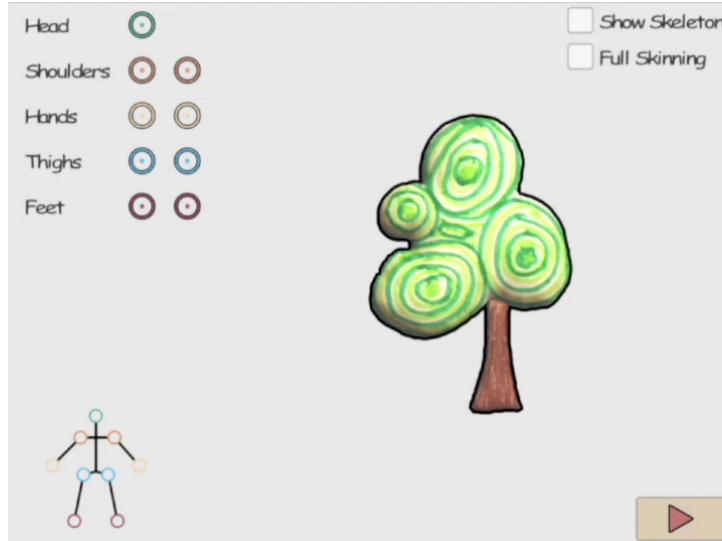
## Interaction: Simple Animation





# The Model Editor

## Interaction: Simple Animation





# The Model Editor

## Character Animation: Skeleton Embedding

Head



Shoulders



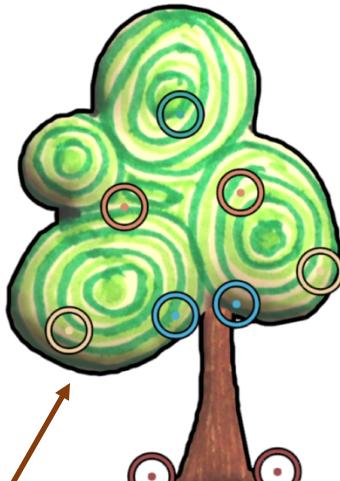
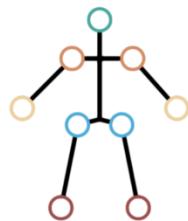
Hands



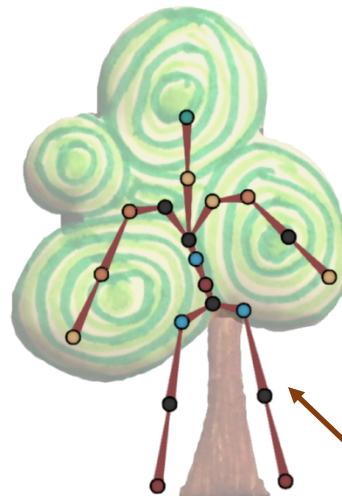
Thighs



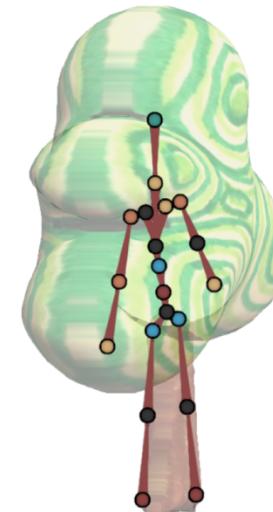
Feet



The user needs to place  
the 9 of 20 joints



The system compute the others  
by using predefined parameters

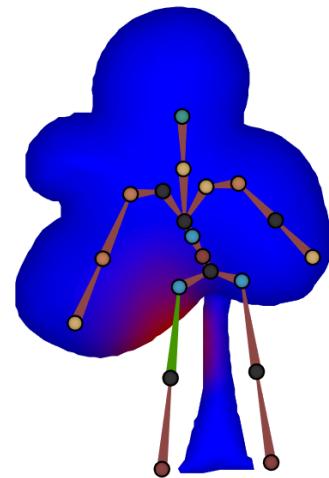




# The Model Editor

## Character Animation: Rigging

1  
0

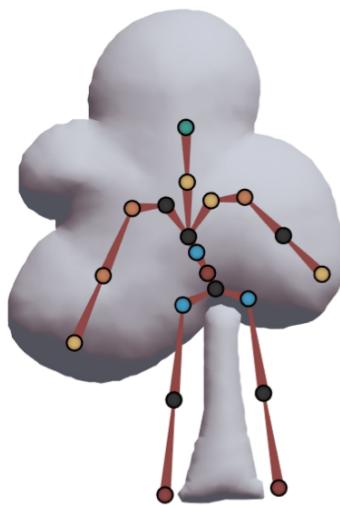


Skinning method:  
Pinocchio - Baran et al. 2007

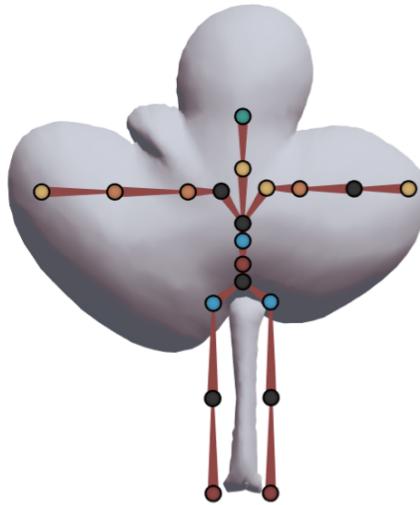


# The Model Editor

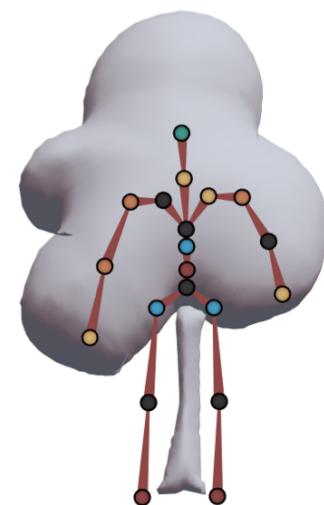
## Character Animation: Rigging



(a) Embedded skeleton



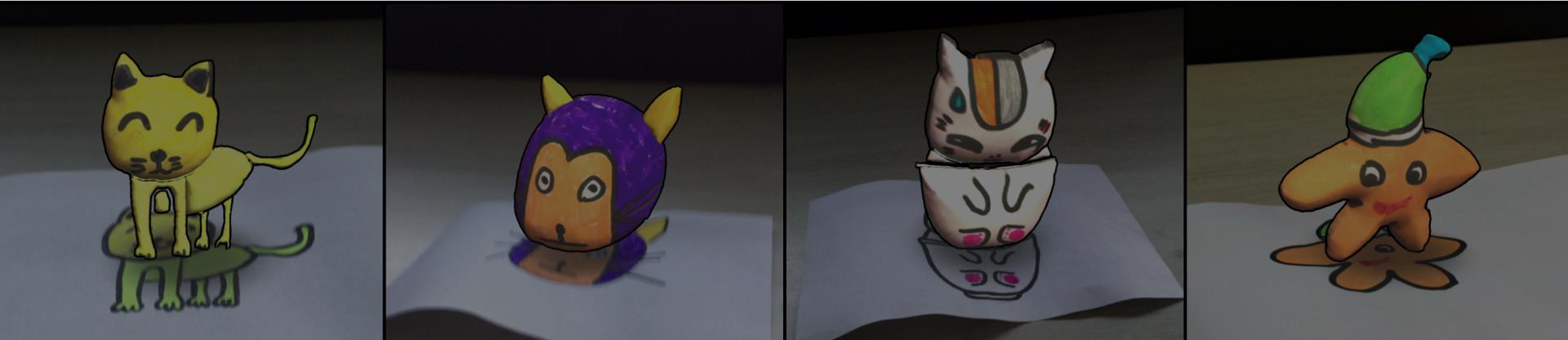
→ (b) T-pose correction



→ (c) Play animation

Skinning method:  
Pinocchio - Baran et al. 2007

# RESULTS





Test on a  
1.3GHz iPad  
Mini 2

# Measured Performance

Table 1: Mesh statistics for examples

	Cherry	Bunny	Tree	Bear
Regions	7	8	11	11
Vertices	3600	3036	2700	4594
Triangles	21516	18096	16056	27432

Table 2: Timing statistics for examples (ms)

	Cherry	Bunny	Tree	Bear
Segmentation	89	95	71	54
Triangulation	51	38	55	61
Inflation	501	512	576	583
Total	641	645	702	698

Sufficient for  
real-time  
interactions

# USER STUDY





# User Study

## Evaluated Systems

- MagicToon: our interactive 2D-to-3D modeling system on mobile platforms
- RigMesh (Borosan et al. 2012): a sketch-based 3D modeling system on Windows platforms
- Chromville: an AR coloring pages application on mobile platforms

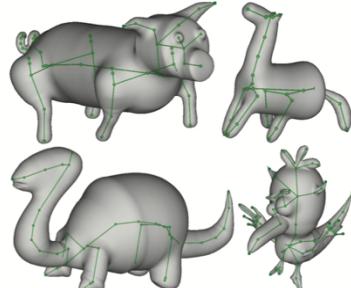


Figure: models created by *RigMesh*  
(Borosan et al. 2012)



Figure: A screenshot of *Chromville*

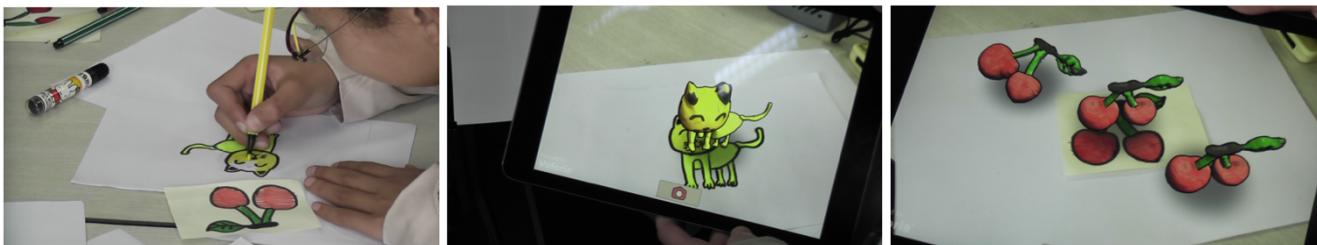


# User Study Participants

- 43 participants, 18 male and 25 female, aging from 10 ~ 13



(a)



(b)



# User Study

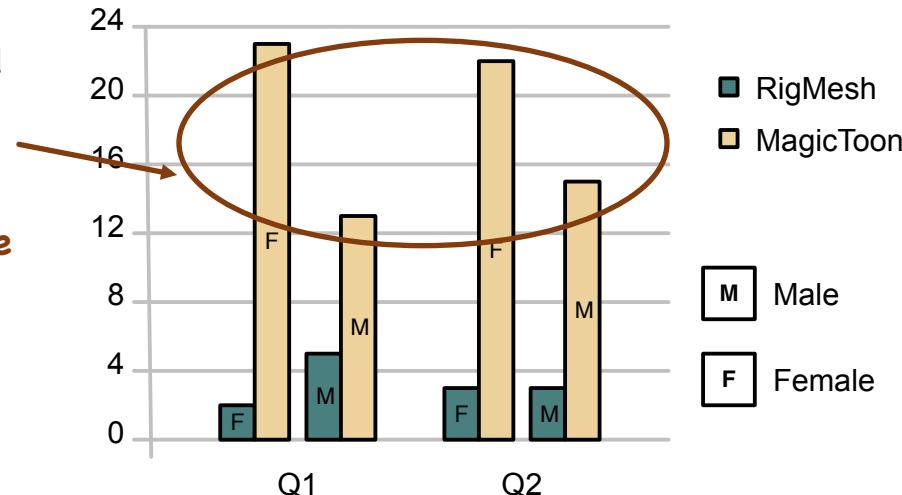
## Experimental Design and Procedure

- Each subject had to accomplish four tasks:
  - **Task<sub>rigO</sub>**: use *RigMesh* to model a creative object.
  - **Task<sub>mago</sub>**: use *MagicToon* to model the same object in Task<sub>rigO</sub> by using the model creator.
  - **Task<sub>mags</sub>**: use *MagicToon* to author a cartoon scene by using our interactive model editor.
  - **Task<sub>chrs</sub>**: use *Chromville* to color a template page of a cartoon scene in line drawing.
- A questionnaire with 6 questions to measure the six dimensions of NASA-TLX and 5 additional questions



# User Study Results

A majority preferred the drawing input procedure and textured results of MagicToon than those of RigMesh

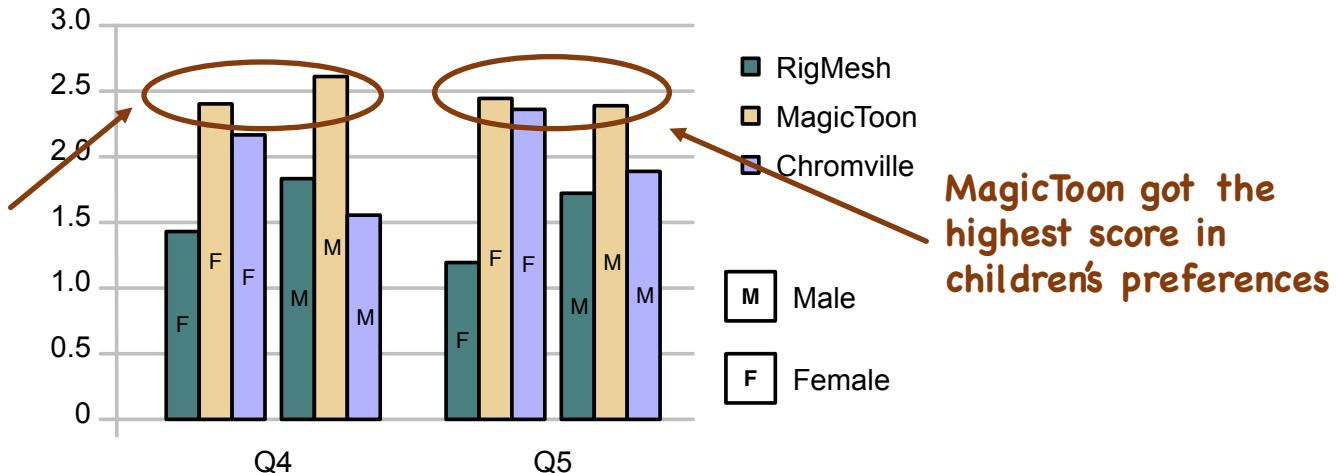


- Q1: which one do you prefer to use to model an object, RigMesh or MagicToon?
- Q2: which type of models do you prefer, RigMesh or MagicToon?



# User Study Results

MagicToon got the highest score in stimulating children's creativity



MagicToon got the highest score in children's preferences

- Q4: Rank the three systems according to their supports for your imagination and creativity from high to low.
- Q5: Rank the three systems according to your preference from high to low.



# User Study

## Differences between the preferences of male and female

Female enjoyed in coloring much more than male and became frustrated more easily when using RigMesh

Q4	RigMesh	Chromville	MagicToon
Female	16%	32%	52%
Male	16.7%	16.7%	66.6%

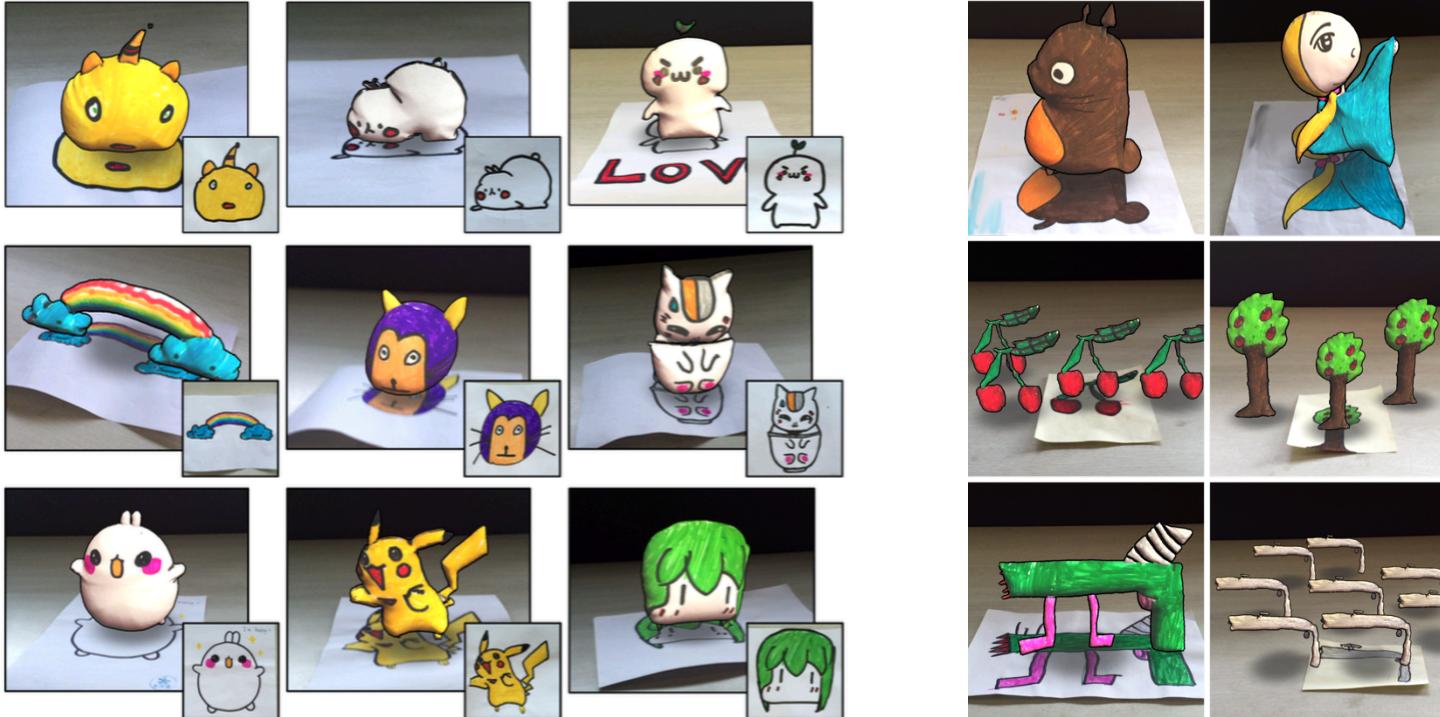
Q5	RigMesh	Chromville	MagicToon
Female	8%	44%	48%
Male	27.8%	22.2%	50%

MagicToon gave more control and freedom to the children

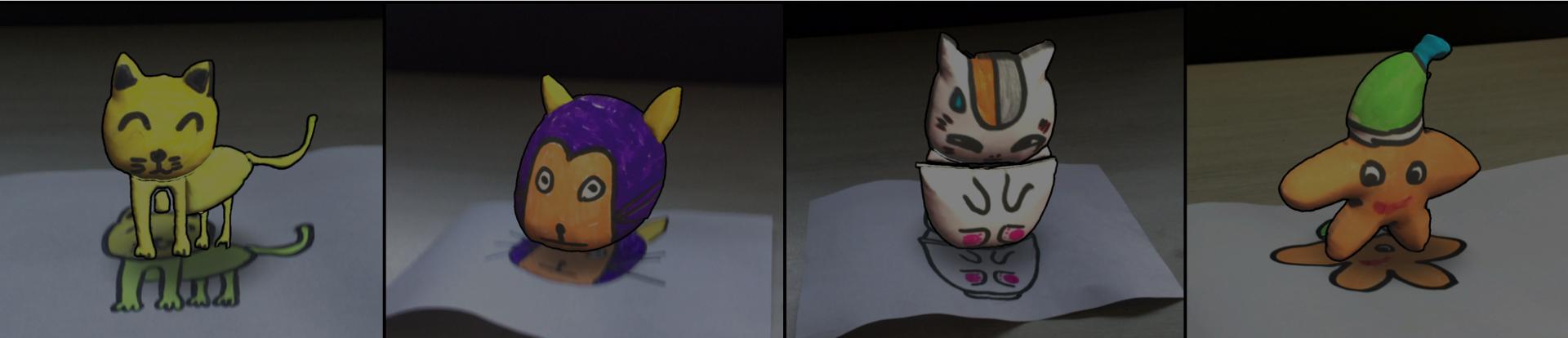
- Q4: Rank the three systems according to their supports for your imagination and creativity from high to low.
- Q5: Rank the three systems according to your preference from high to low.



# User Study Results



# SUMMARY





# MagicToon

## Conclusions

- A 2D-to-3D cartoon modeling system with mobile AR
  - Fully leverage children's drawing skills in the real-world
  - Generate textured 3D cartoon models from 2D drawings automatically
  - Allow children to author creative cartoon scenes
- Conduct a user study
  - Compared with *sketch-based systems*
    - Time-saving, textured, sketch on real paper, AR enabled
  - Compared with *AR coloring books*
    - Create personalized models, control of the sizes and complexity of the shapes



# MagicToon

## Future Work

- Advanced methods to predict relative depth orders
- Synthesize textures for the back faces
- Support storytelling functionalities

# MagicToon: A 2D-to-3D Creative Cartoon Modeling System with Mobile AR

Lele Feng, Xubo Yang, Shuangjiu Xiao

Digital ART Lab

Shanghai Jiao Tong University



1. Sketch cartoon drawings  
in the real world



# MagicToon

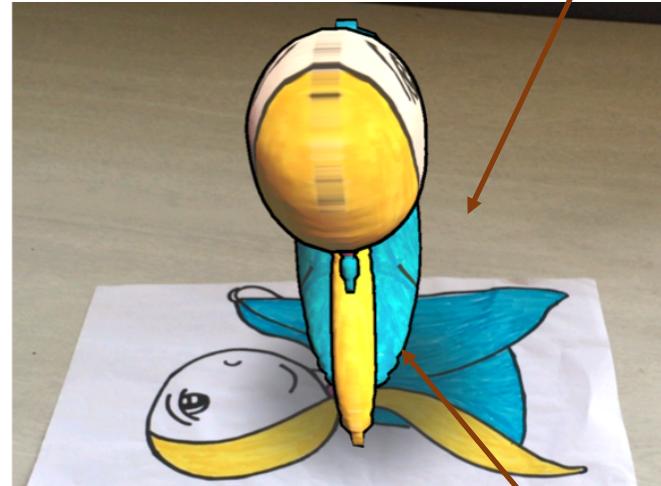
## Limitations

- Surrounding environments influence the robustness of the segmentation algorithm
  - Improve the segmentation algorithm
- Fail to generate models when the outlines are too thin or not enclosed
  - Re-outlining the image!
- Cannot generate sharp models such as cubes
  - Allow users to modify the distance field



# MagicToon

## Limitations



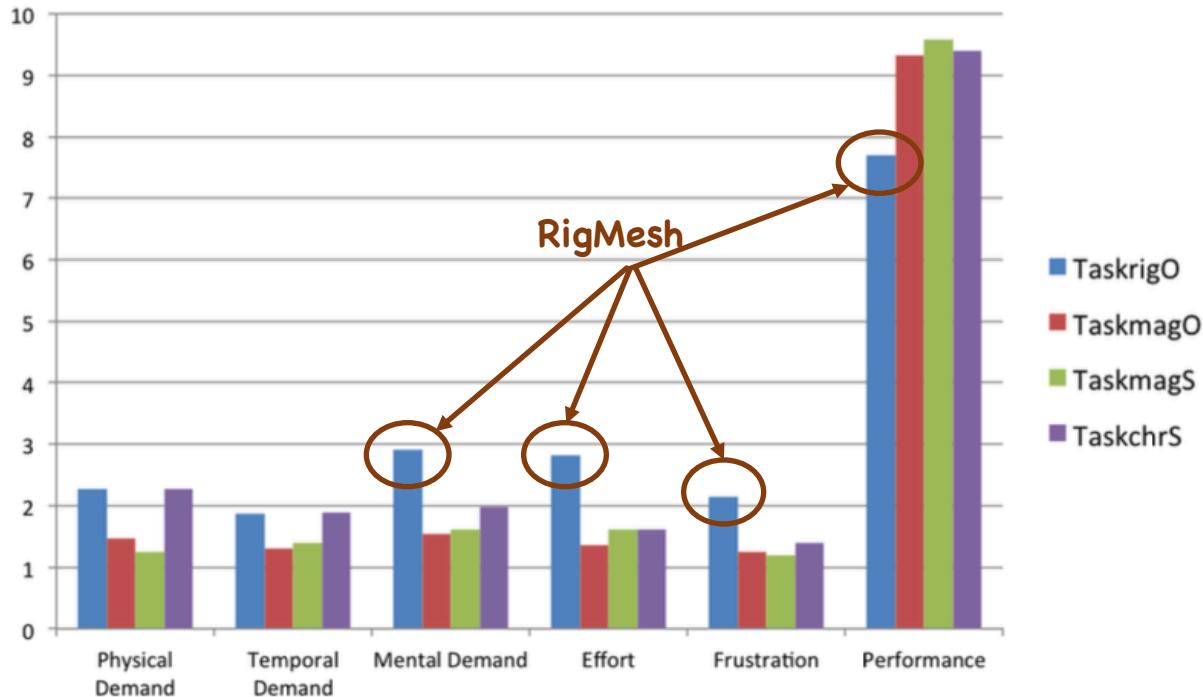
Lack depth orders  
between parts

The same textures  
used for both front  
and back faces



# User Study

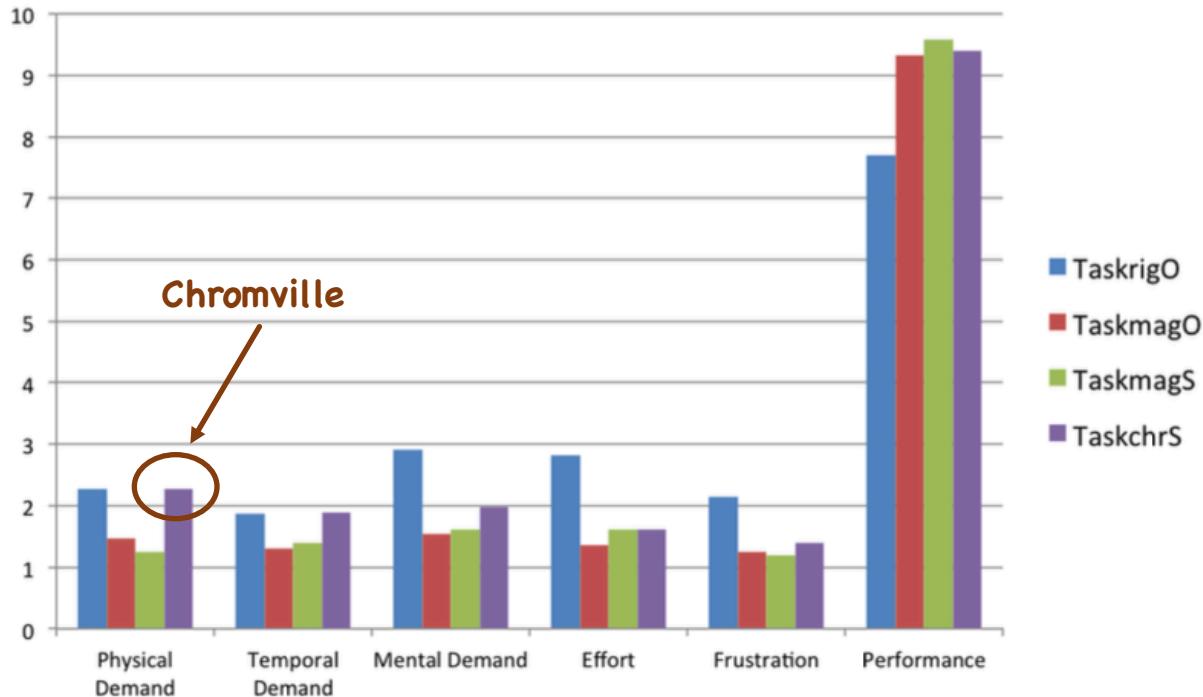
## RigMesh





# User Study

## Chromville





# User Study

## MagicToon

