SIGGRAPH ASIA 2015 KOBE

# Physics Simulation R&D at SQUARE ENIX®

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# Physics Simulation R&D at

SQUARE ENIX®

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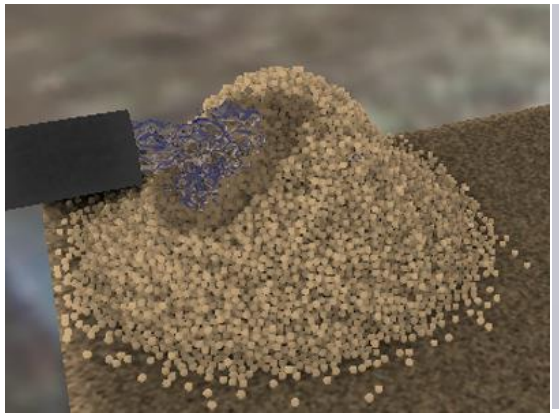
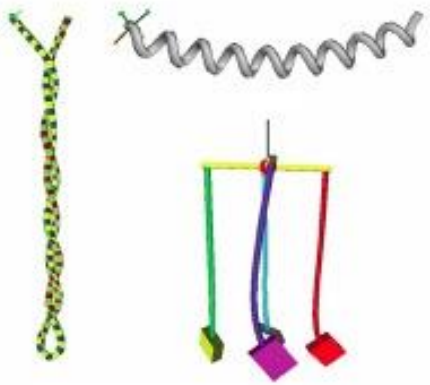
# Self introduction

- Academic background
  - PhD and post-doc at Tokyo University (2012)
  - Research on physics simulation
    - Mostly hairs and sand



Particle simulation & wetting sand

Hair simulation & wetting hair



Other simulations

# Self introduction

- Working at Square Enix
  - Joined the Advance Technology Division in 2013
  - Physics simulation systems of cloth, hair, fur, …
    - Runtime systems & authoring tools
  - Used on several on-going games projects
    - Main project = Final Fantasy XV *(2nd Business Division)*

# Disclaimer

- Many screenshots/ videos
  - They are from my prototyping environment
  - Most are from old work-in-progress experiments
  - They are not representative of final quality

- Special thanks to Mr. Tabata and the artists of the Second Business Division

# Outliner

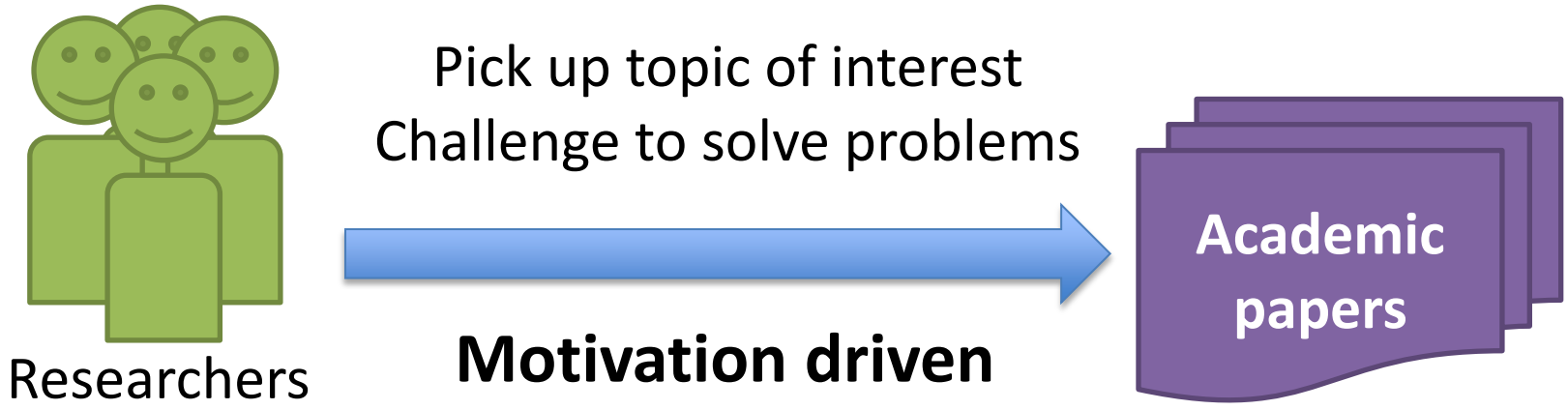
- Introduction
- Cloth
- Hair
- Wind
- Foliage and fur
- Conclusion

# Introduction

- Topic of this talk
  - Sharing R&D experience in creating simulation systems for AAA title games
  - Difference between Academia & Game Industry

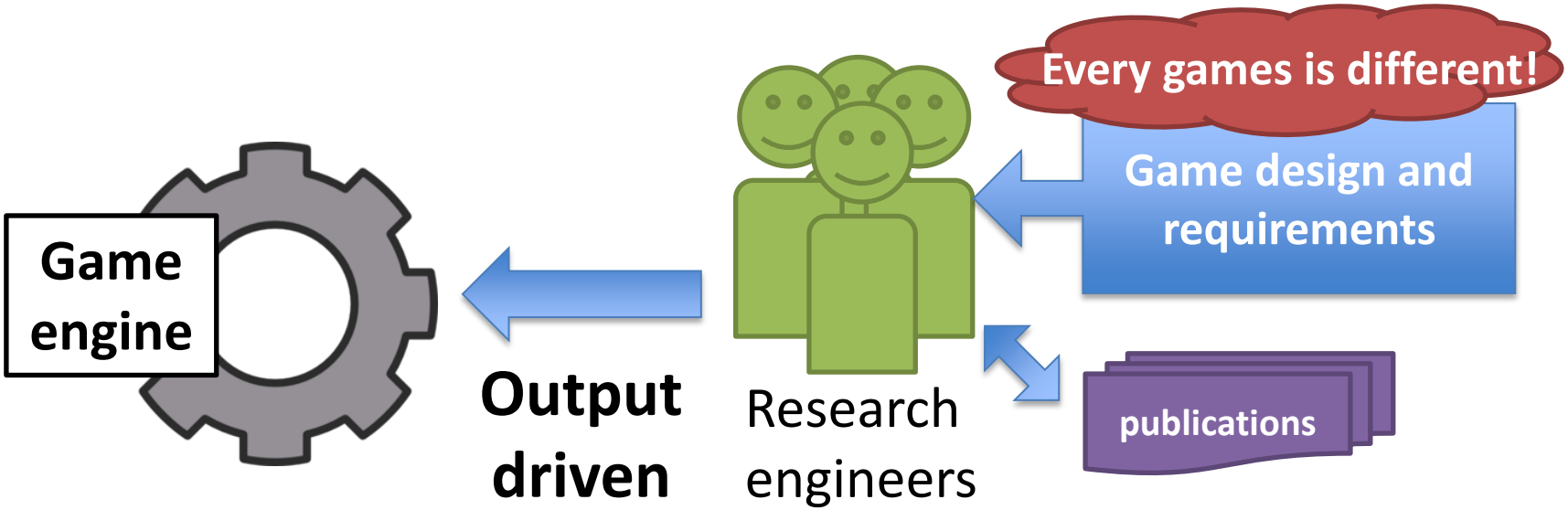
# Introduction

- **Academia** vs Game Industry
  - Driving force towards goal



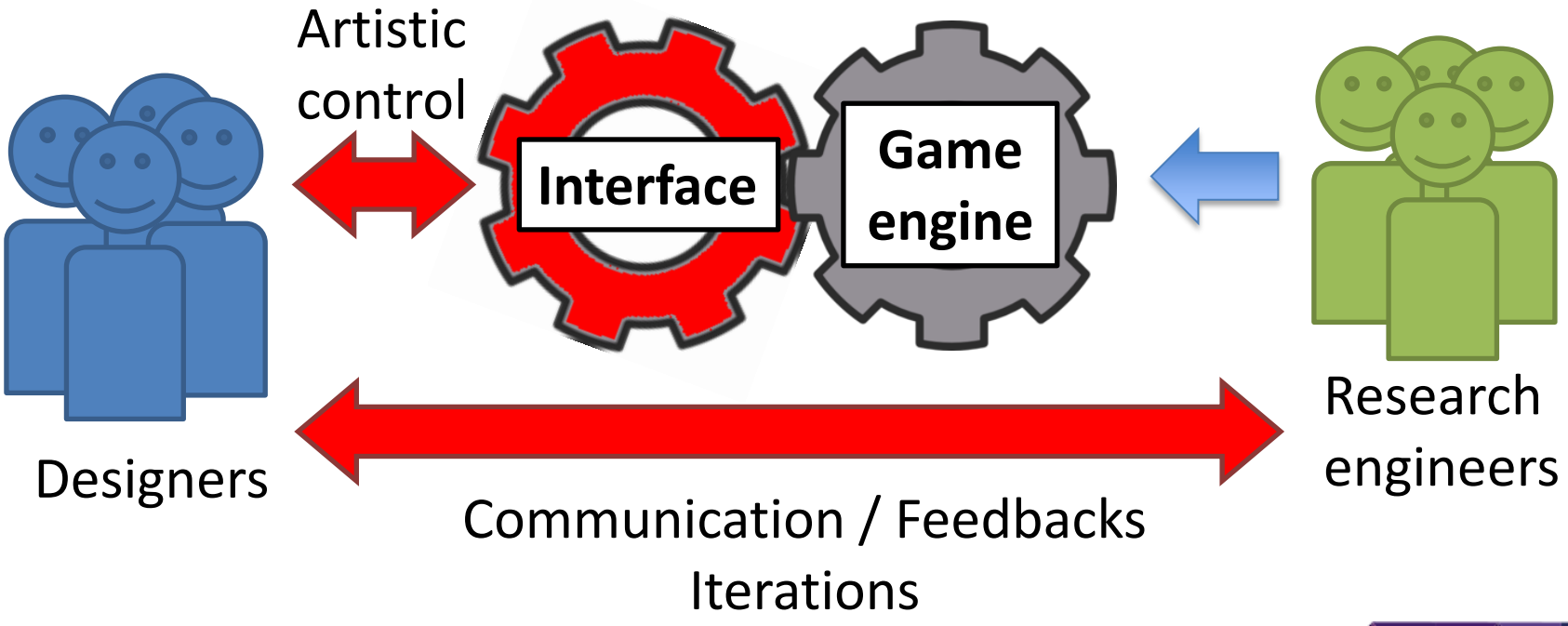
# Introduction

- Academia vs **Game Industry**
  - Driving force towards goal



# Introduction

- Academia vs **Game Industry**
  - Working with professional designers



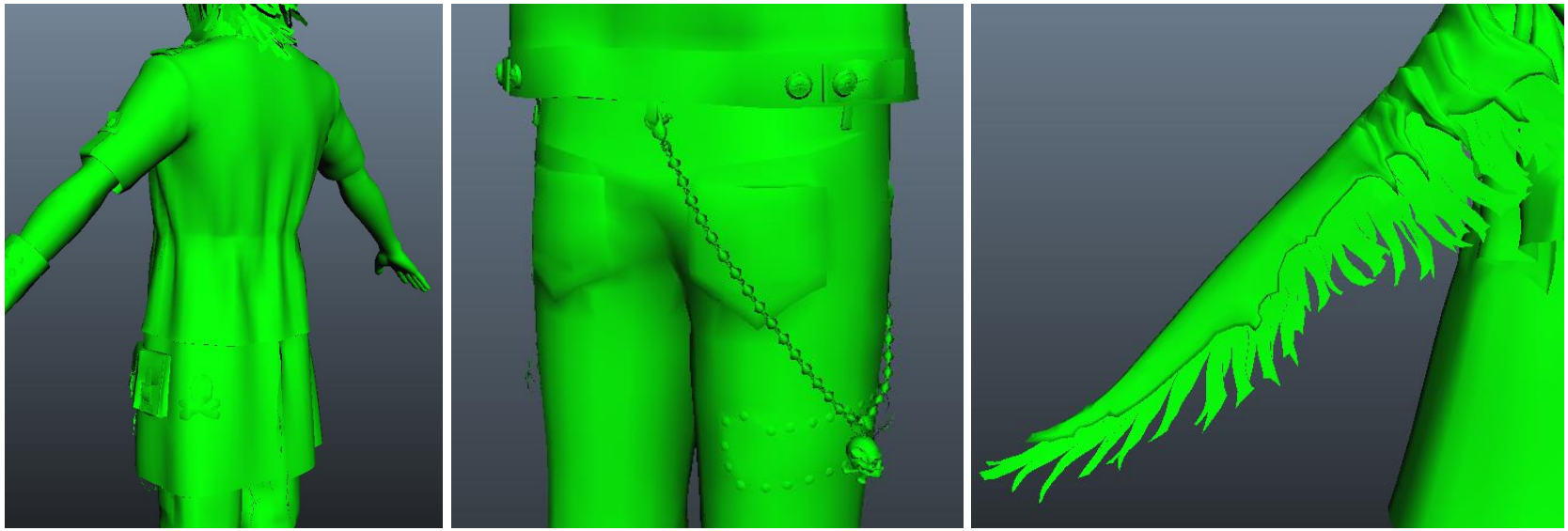
# Introduction

- Academia vs **Game Industry**
  - Doing tricks or fakes is OK
    - We don’t do this in the academic area
  - Sharing limited resources with AI, Graphics, etc.,
    - Especially on gaming consoles

# Cloth simulation

# Cloth simulation

- Our goal
  - To simulate jackets, accessories and all shaky soft bodies on characters and monsters



# Cloth simulation

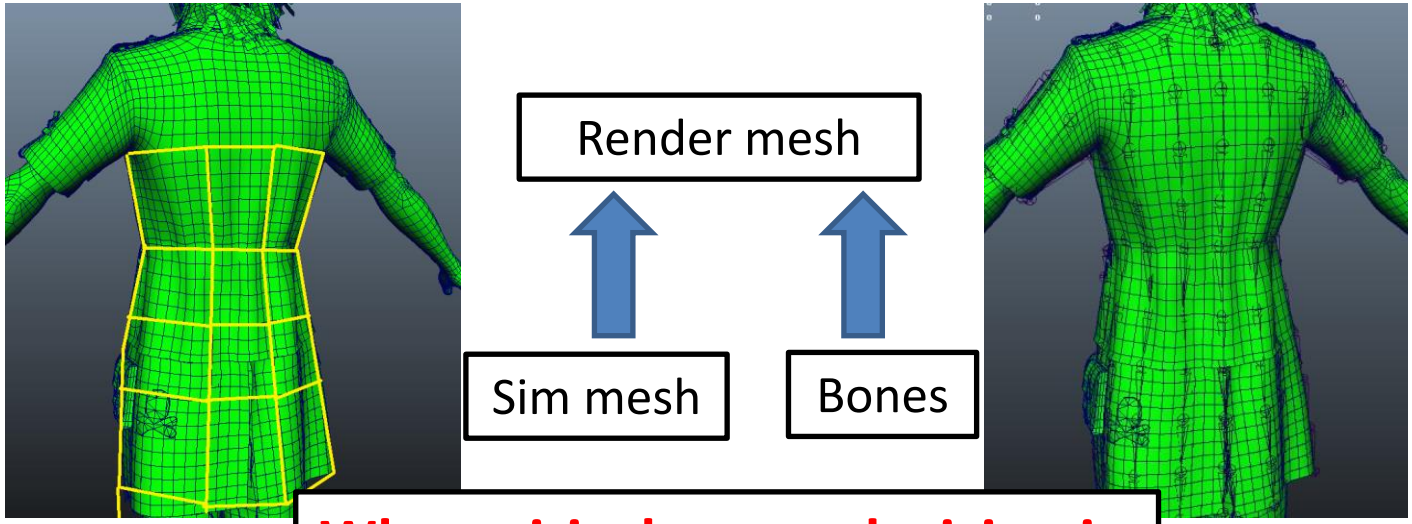
- What are our choices ?
  - Lot of simulation methods in the field
  - Simulation on vertices or bones
  - CPU and GPU implementation

# Cloth simulation

- What did we do ? and why ?
  - Simulation method:
    - Fast and stable particle-based method
  - Simulation on vertices or bones
    - Bone-based (More flexibilities and controls)
  - CPU and GPU implementation
    - We can switch, depending on whether GPU is heavily used for graphics or not

# Cloth simulation

- Vertex-based vs. bone-based

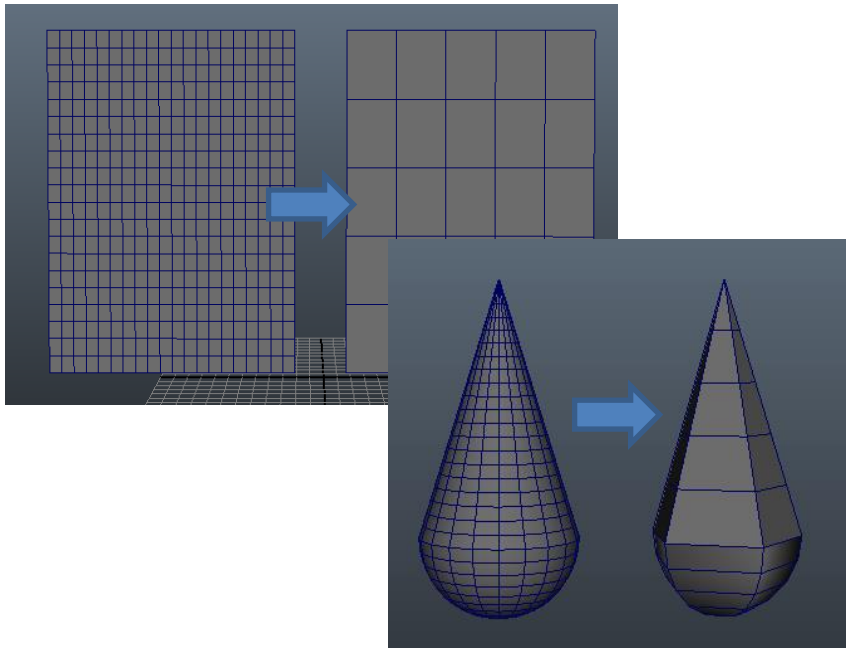



Lower resolution sim … onal bones driving render … ender mesh

**What critical to our decision is how designers setup physics**

# Cloth simulation

- **Vertex-based** vs. bone-based
  - Vertex-based examples



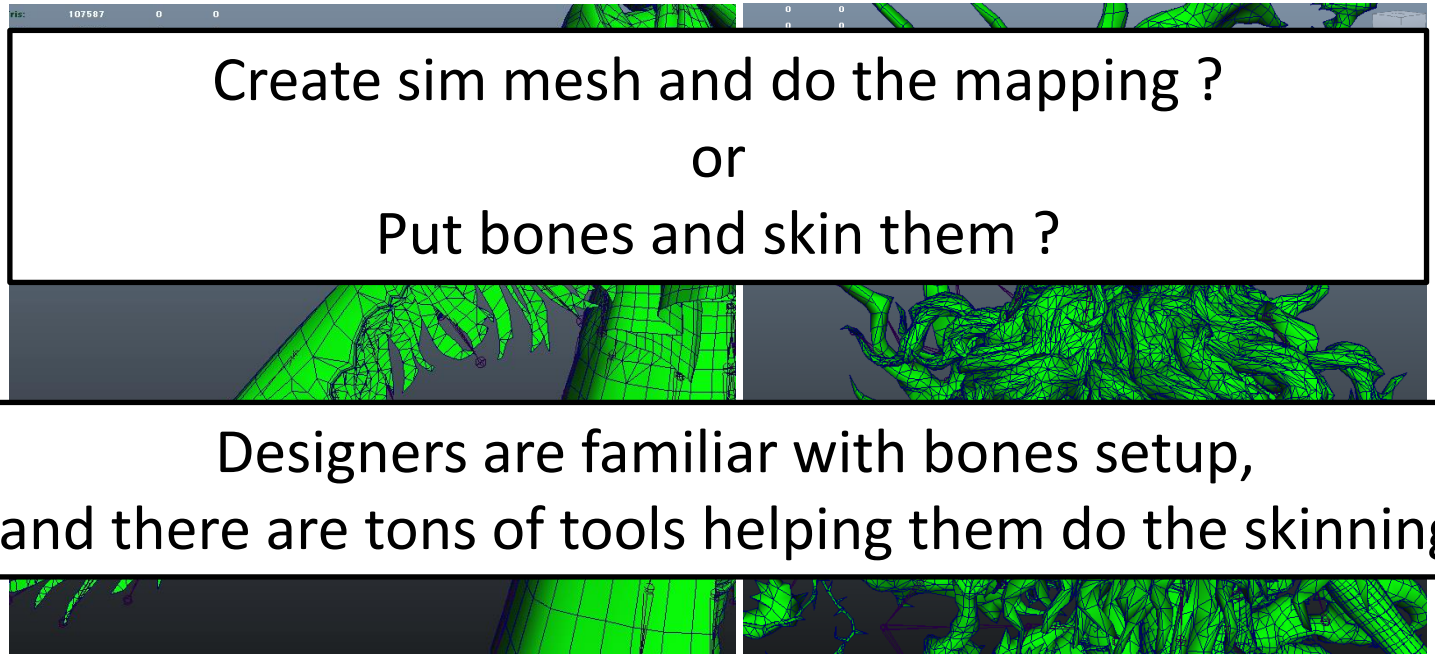
Create low res. sim mesh from render mesh

Map sim mesh with render mesh

**Done! Easy!**
Simple shapes can be easily automated

# Cloth simulation

- Vertex-based vs. **bone-based**
  - But how about these assets ?

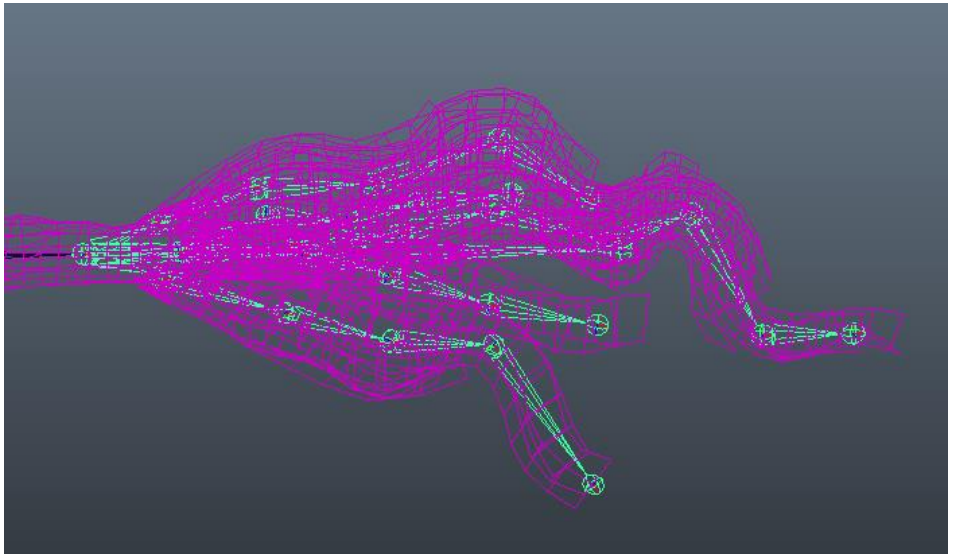


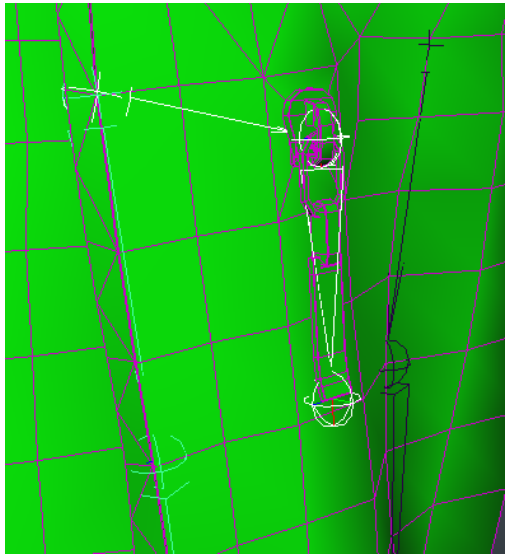
Create sim mesh and do the mapping ?
or
Put bones and skin them ?

Designers are familiar with bones setup,
and there are tons of tools helping them do the skinning

# Cloth simulation

- Vertex-based vs. **bone-based**
  - Branching and layering → bone-based





# Cloth simulation

- Vertex-based vs. **bone-based**
  - Animation blending
    - Cinematic scene: more like a performance, less like a natural phenomenon
    - Working on bones gives artists both simulation and animation control

# Cloth simulation

- Results

# Cloth simulation

- Results



MAIN CHARACTER DESIGN : TETSUYA NOMURA

# Cloth simulation

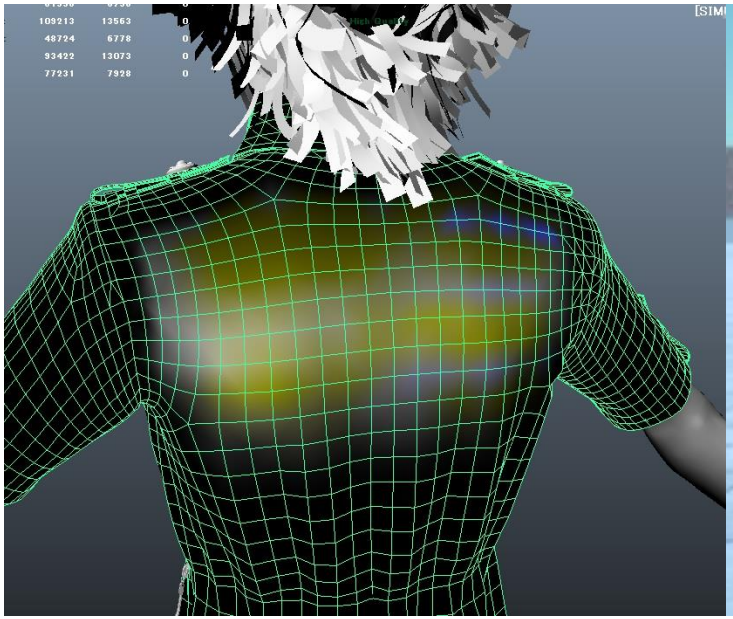
- Difficulties and limitations
  - Developing realism (simulation) on top of unrealism (games motion)
    - Fast motion → breaking, tunneling collision problem
    - Limit an effect of fast motion on cloth, yet preserve degrees of freedom as much as possible

# Cloth simulation

- Tricks and tips
  - For designer's ease of use, avoid real physical units (e.g. Newton per meter ?!). Instead, use normalized parameters [0=soft 1=hard]
  - Simulation + Vertex animation (Flappy cloth)

# Cloth simulation

- Tricks and tips



# Cloth simulation

- Tricks and tips
  - Make an authoring system highly customizable as much as possible
    - Not necessary to be just point masses on bones and a network of constraints
    - Make it possible to place point masses and constraints anywhere -> maximize artists creativities

# Cloth simulation

- Results (bonus)
  - Something from artists creativities

# Cloth simulation

- Results (bonus)
  - Something from artists creativities

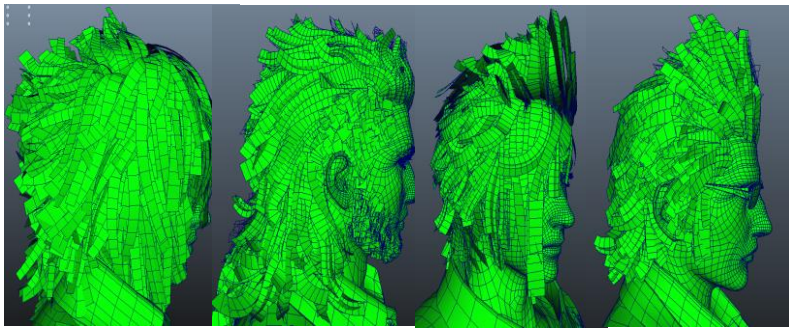


MAIN CHARACTER DESIGN : TETSUYA NOMURA

# Hair simulation

# Hair simulation

- Our goal
  - Simulate all sorts of stylish hairstyles, at high quality
  - The design & the look are very important

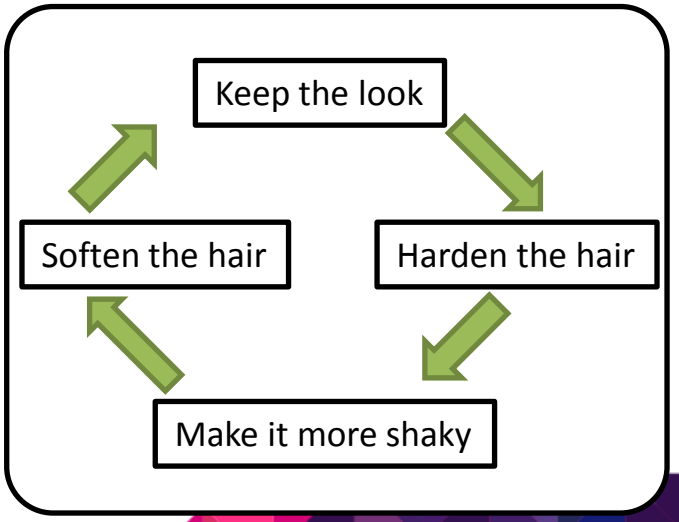


# Hair simulation

- Problems
  - Usual approaches freely simulate very soft hairs and do not “protect” the hairstyle

*A. Selle et.al, SIGGRAPH 2008*

  - Conundrum: hairs need to be stiff and soft at the same time !



# Hair simulation

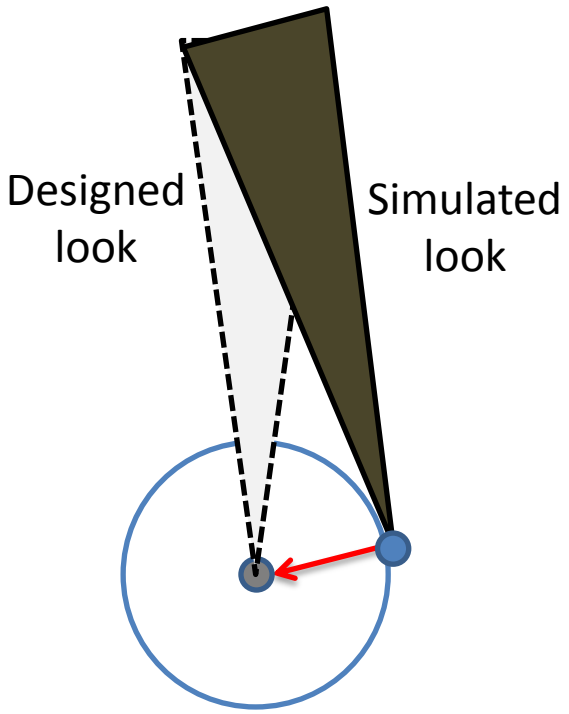
- What did we do ? and why ?
  - Bone-based
    - Rich set of constraints
    - Easier to provide artistic controls
    - Lower designers' learning cost:
      one system for both hair and cloth

***Constraints***
*- Length*
*- Uniform cone*
*- Non-uniform cone*
*- Long range attachment*
*- Shape matching*
*- Pin constraint*
*- Sphere constraint*
*- Double sphere constraint*
*- Spring constraint*
*- Attribute transfer link*

***Collisions***
*- Sphere*
*- Capsule*
*- Triangle*
*- Inverse sphere*
*- Inverse capsule*
*- Plane*

# Hair simulation

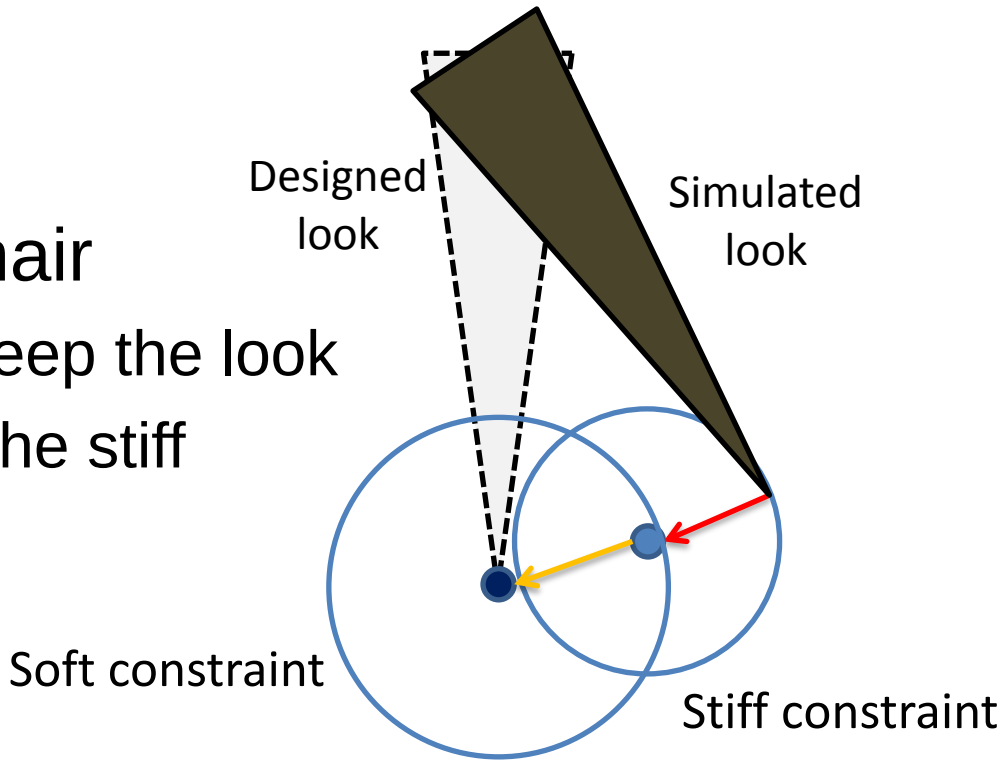
- Tricks
  - Shaky hardened hair
    1. Stiff constraint to keep the look




Stiff constraint to keep the look

# Hair simulation

- Tricks
  - Shaky hardened hair
    1. Stiff constraint to keep the look
    2. Soft constraint on the stiff




Stiff when idle, shaky when in action

# Hair simulation

- Results

FINAL FANTASY XV PAX Prime 2015

# Hair simulation

- Difficulties and limitations
  - Collision still breaks the look (a bit)
    - Use only sphere and capsule shapes for colliders
  - When you give artists flexibility
    - → they tend to pay attention to every small detail
    - → consume too much resources
    - → Visualize budget for them

# Wind

# Wind

- Our goal
  - Cloth and hair need wind to look believable
  - Look not too procedural

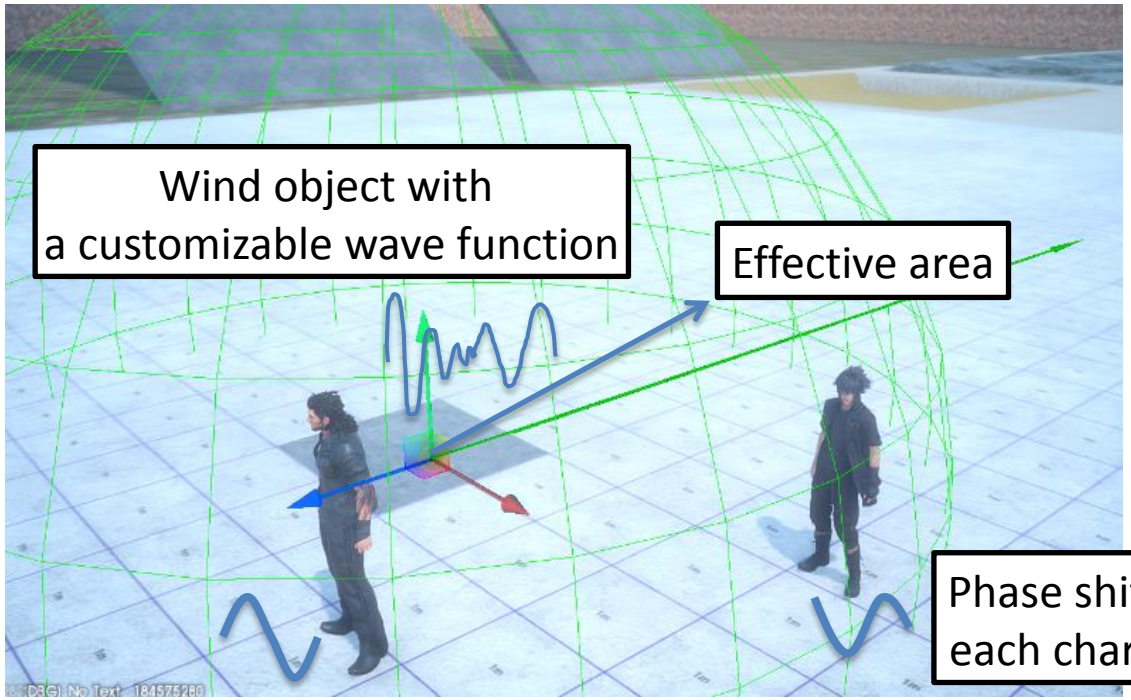

FINAL FANTASY XV PAX Prime 2015

# Wind

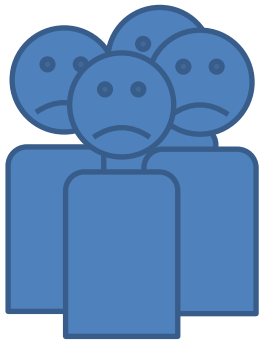
- What are our choices ?
  - Fluid simulation → Big no
  - Wave functions

# Wind

- What did we do ? and why ?
  - Wave functions, area, dynamics, phase shift



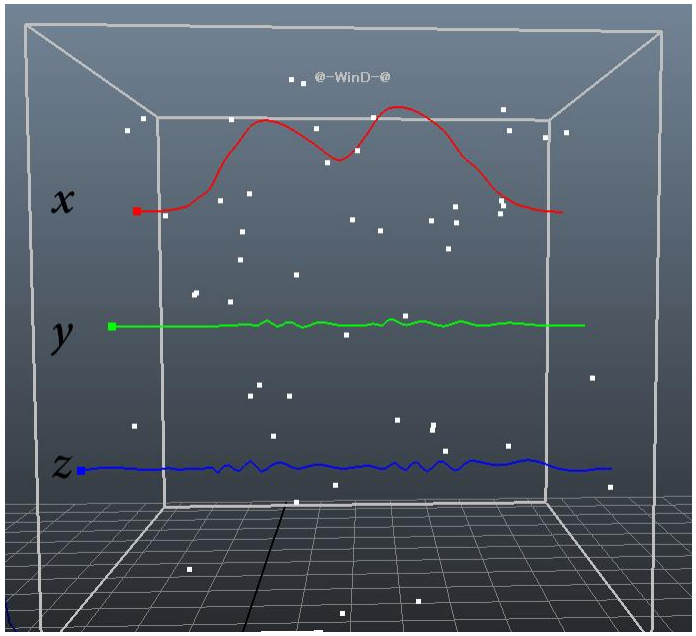

Designers have an image of wind, but struggle to create a wave fn.

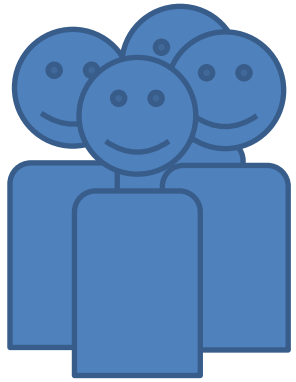


Designers

# Wind

- What did we do ? and why ?
  - Wave functions → Hand drawing wind

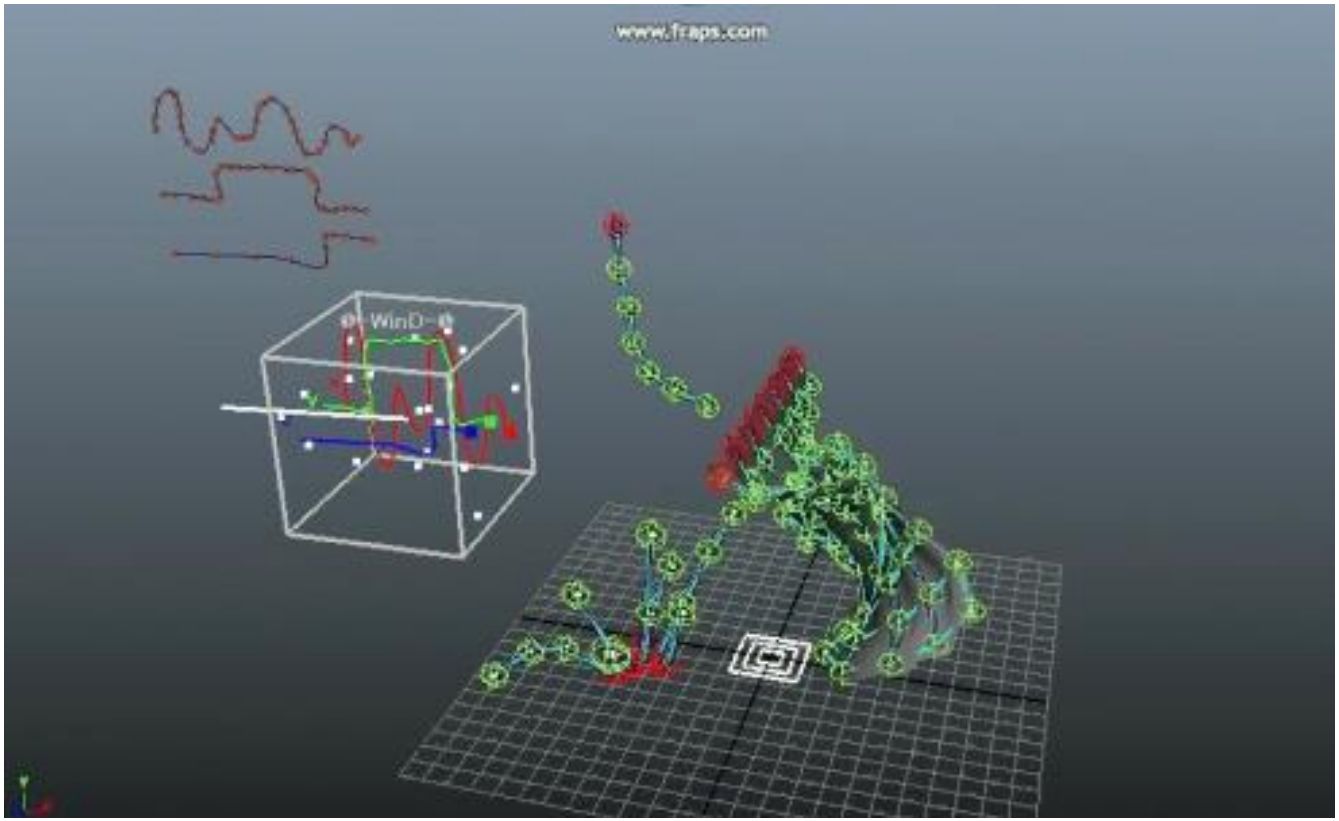


Designers

# Wind

- Results



# Wind


FINAL FANTASY XV PAX Prime 2015

# Foliage and fur

# Foliage and fur

- Our goal
  - Tons of foliage and fur in a scene
  - Waving in the wind naturally

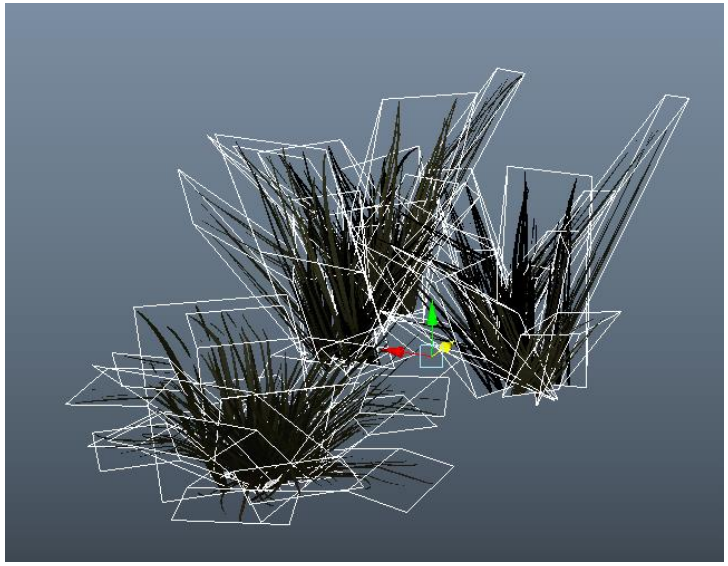
# Foliage and fur

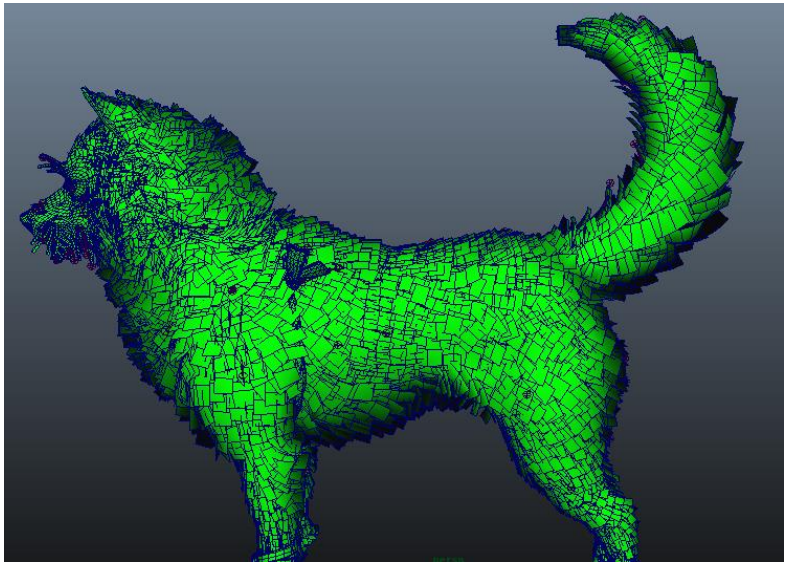
- What is the output ?
  - Rain in FFXV
    - Wet the dog

Dry dog Wet dog

# Foliage and fur

- What are our choices ?
  - Simulation → No, too costly
  - Procedural vertex animation



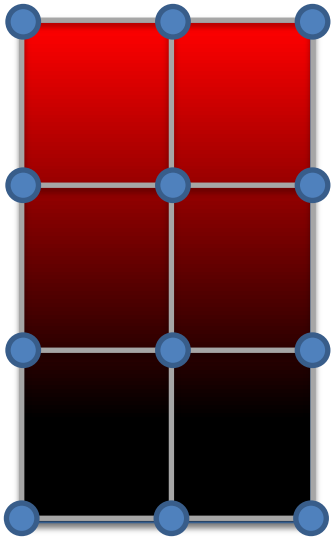


 MAIN CHARACTER DESIGN : TETSUYA NOMURA

# Foliage and fur

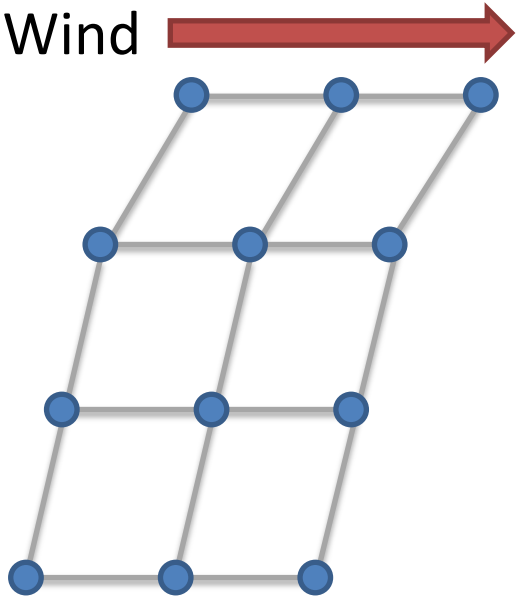
- What did we do ? and why ?
  - Do procedural vertex animation

Vertex color

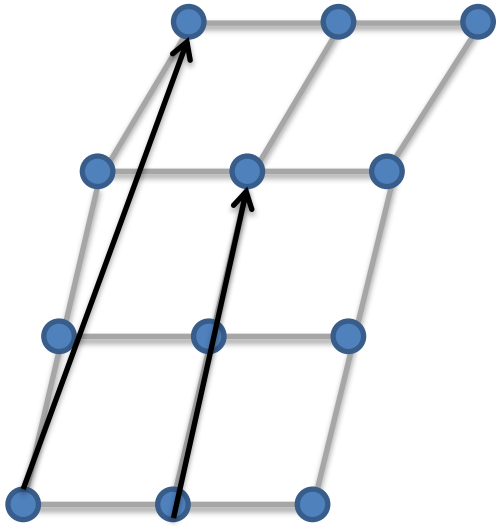


wind influence quantity

Wind

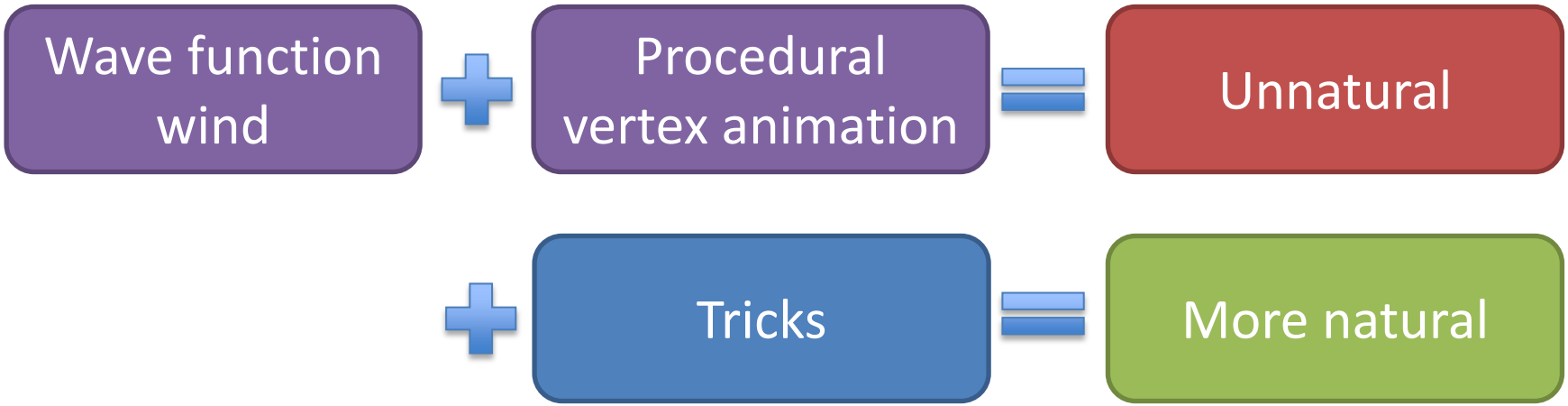


Length constraints



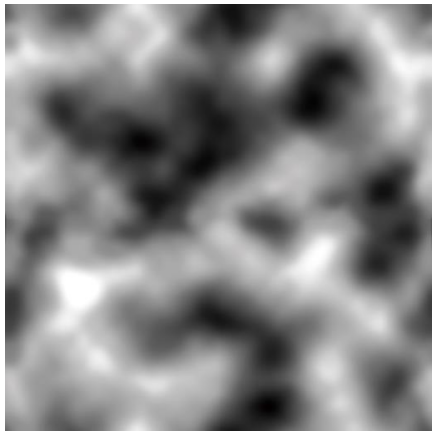
# Foliage and fur

- What did we do ? and why ?
  - Do procedural vertex animation



# Foliage and fur

- What did we do ? and why ?
  - Do procedural vertex animation
  - More random look: add noise map



Noise map

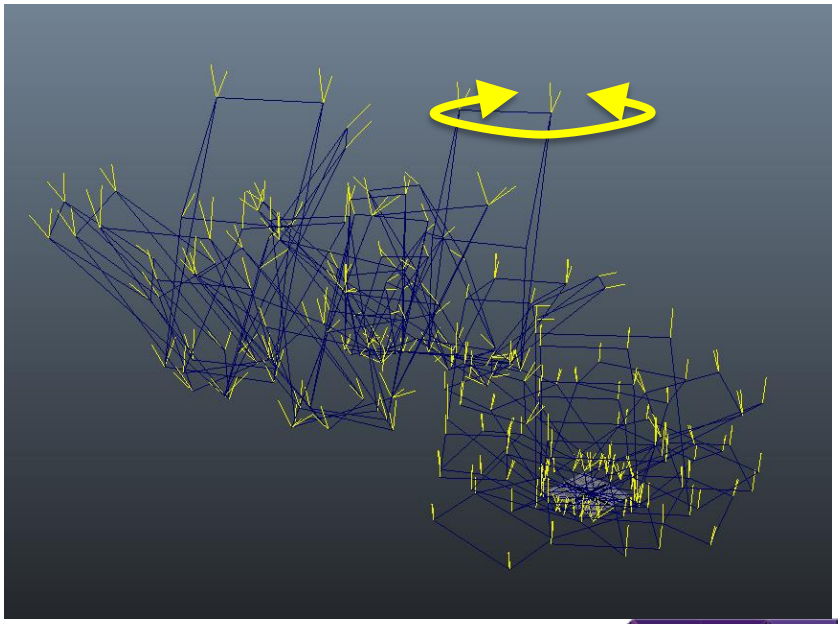
# Foliage and fur

- What did we do ? and why ?
  - Still looks procedural → random travelling wind

Travelling wind

# Foliage and fur

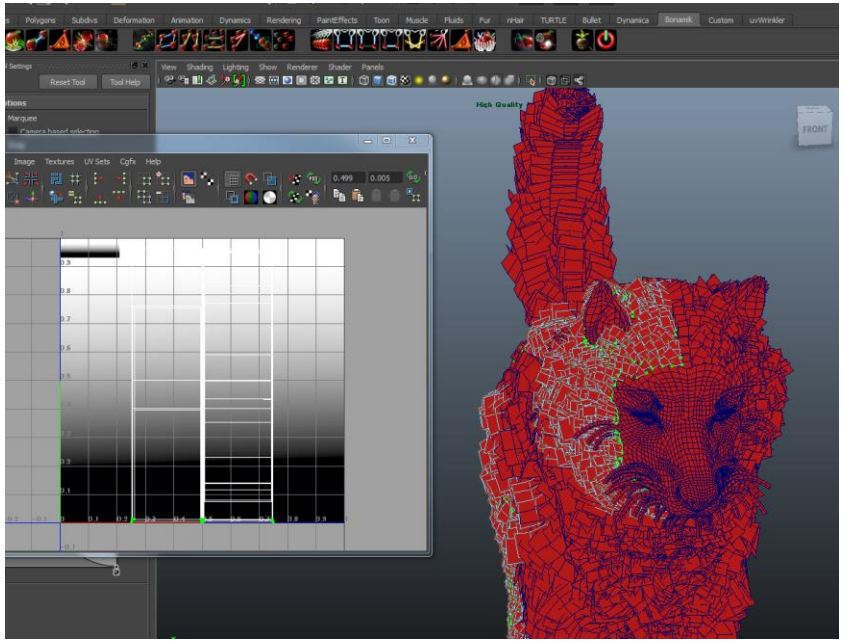
- Tricks
  - Vertex animation + normal vector animation
    - Fake the effect of leaves overlapping onto each other



# Foliage and fur

# Foliage and fur

- Fur vertex animation
  - Waving fur is pretty much the same with foliage
  - Color texture instead of vertex color

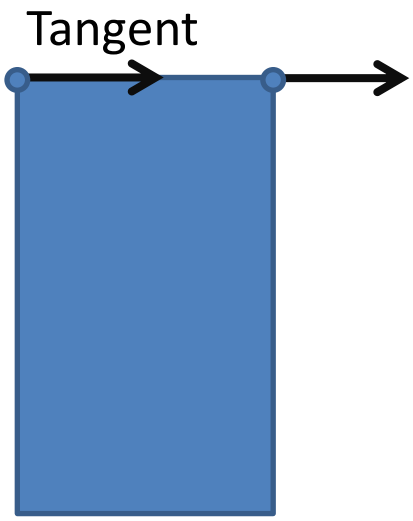


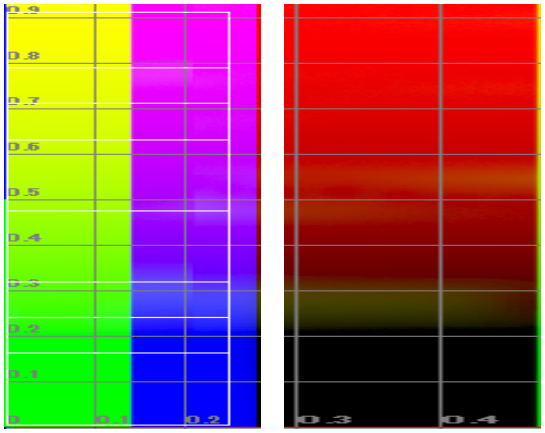
# Foliage and fur

 MAIN CHARACTER DESIGN : TETSUYA NOMURA

# Foliage and fur

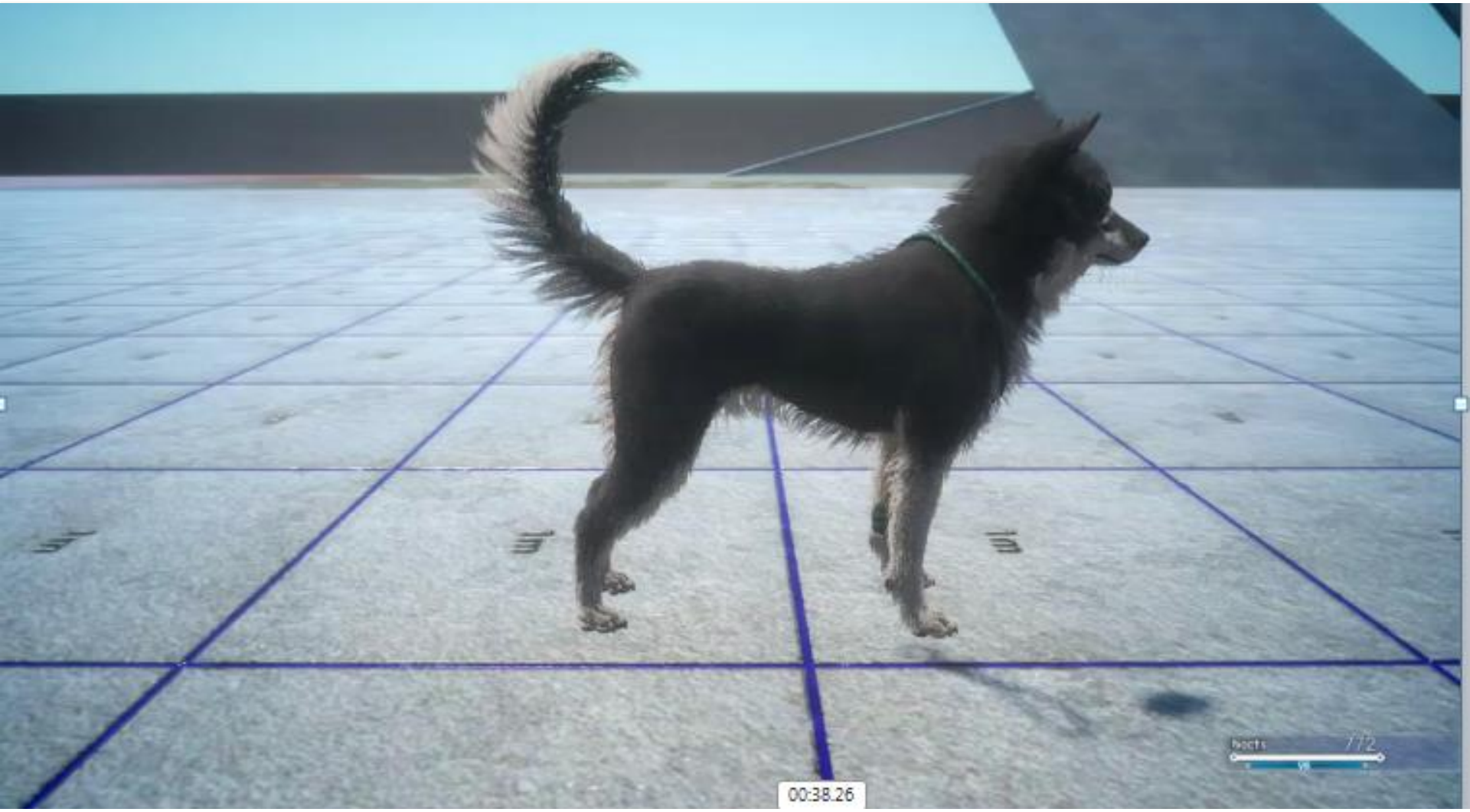
- Fur vertex animation
  - Procedural wet fur: mesh shrinking



G-channel : + direction
B-channel: - direction

# Foliage and fur





MAIN CHARACTER DESIGN : TETSUYA NOMURA

# Summary

- Academia vs. Game Industry:
  - Motivation driven vs. production driven
  - Very limited resources on gaming consoles
  - The best tech is not always the best approach

- R&D in soft body simulation
  - Fur, Hair, Cloth, etc…
  - Flexible/reusable system
  - Artists-friendly interface→cool results

# Conclusion

- What I like about the game industry
  - → Heterogeneous environment
  - → A lot of smart, talented people
  - → “Hard” science + possibility for tricks = fun
  - → Experiment on game assets
  - → Cross-disciplinary team results

# Special thanks


- To the 2nd business division and the Final Fantasy XV team for giving me access to awesome assets and letting me share these results
- My colleagues from the Advanced Technology Division

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# Q&A

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