



WARHØRSE



# KINGDOM COME: DELIVERANCE CHARACTER CLOTHING

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WARHORSE STUDIOS

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# OUTLINE

- MOTIVATION AND CHALLENGES
- LAYERING OF MORPHED MESHES
- RAY-CASTING
- CONCLUSION



# MOTIVATION AND CHALLENGES



# RPG GAMES

- PLAYER CAN KILL/LOOT ANYBODY
- PLAYER CAN EQUIP ANY ITEMS FOUND
  - CAN WEAR MORE ITEMS TOGETHER
- OUR RPG GAME
  - NPCs CAN DO THE SAME
  - REALISM TOGETHER WITH THE VARIETY





# OUR ISSUE - COMBINATIONS



# POSSIBLE APPROACHES

- SAME SHAPES / MESHES FOR ALL ITEM TYPES
- BIG (SAFE) DISTANCES BETWEEN MESHES
- HAND MADE TUNING FOR ALL COMBINATIONS
- HYBRID APPROACHES ...



# OUR SOLUTION

- GOOD REALISM
- NO ADDITIONAL ARTIST INPUT PER NEW PIECE OF CLOTHING



# LAYERING OF MORPHED MESHES



# OUR SETUP (SIMPLIFIED)

- CLOTHING LAYERS
  - BODY, CLOTH, CHAINMAIL, PLATE, DECORATION
  - OUTER LAYERS COVER INNER LAYERS
  - INFLUENCE MATRIX



# OUR SETUP (SIMPLIFIED)

- PIECES OF CLOTHING ADAPT
- MORPHED MESHES
  - GUIDE THE ADAPTION
  - STORE VARIATIONS
  - EXPRESS BODY PROPORTIONS (FAT, SLIM)
- MORPHS ARE APPLIED ONCE!



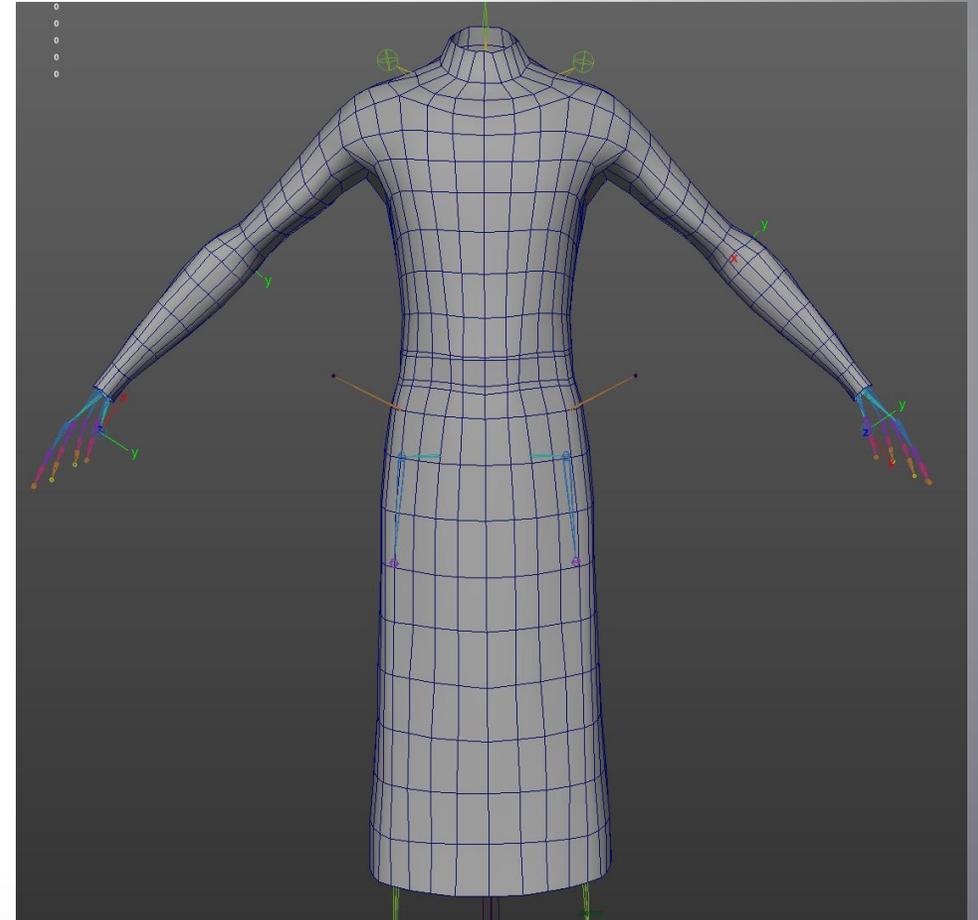
# TERMINOLOGY

- BASE SHAPE
  - ITEM ALONE
  - CREATED BY ARTISTS



# TERMINOLOGY

- SHRUNK SHAPE
  - MAXIMUM ADAPTATION
  - BASE + SHRINK MORPH
  - CREATED BY ARTISTS
    - *COULD* BE GENERATED



# INPUT FROM ARTISTS

- BASE MESH
- SHRINK MORPH
- MATERIAL
  - TEXTURES



# VARIATION MORPHS

- SAME TOPOLOGY, SIMILAR SHAPE
  - REUSE BASE MESH
  - CREATE VARIATION MORPH
  - REUSE SKINNING, UVs, TRIANGLES, NORMALS
  - SAVE DATA, SAVE TIME 😊



# CLOTH LAYER (BASE + VARIATIONS)



# ARMOR LAYER – MORE BASE MESHES



# RAY-CASTING



# LAYERING BY RAY-CAST

- INPUT: A CHARACTER WITH EQUIPPED ITEMS
  - EACH MESH IN THE BASE AND SHRUNK SHAPE



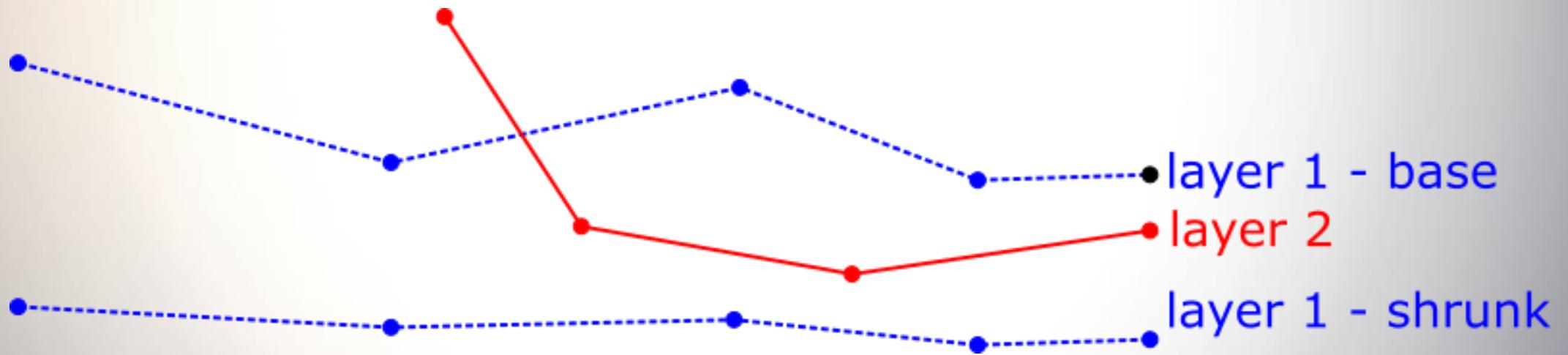
# LAYERING BY RAY-CAST

- OUTPUT: FOR EACH MESH VERTEX A WEIGHT  $W$ 
  - $W$  BLENDS THE BASE AND SHRUNK SHAPE
  - $W = 1$  -> NO ADAPTATION
  - $W = 0$  -> MAXIMAL ADAPTATION



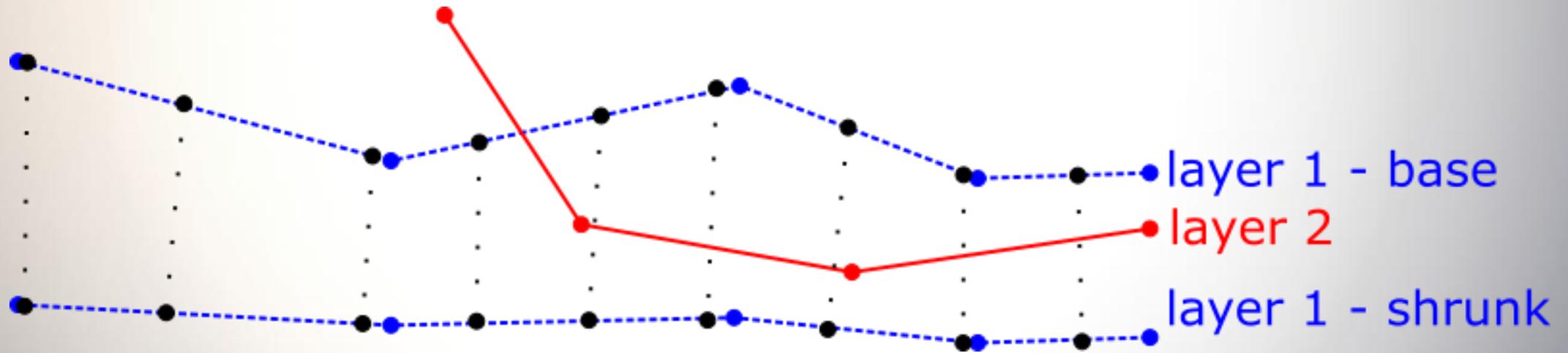
# BASE ALGORITHM

- FOR EVERY PAIR OF MESHES



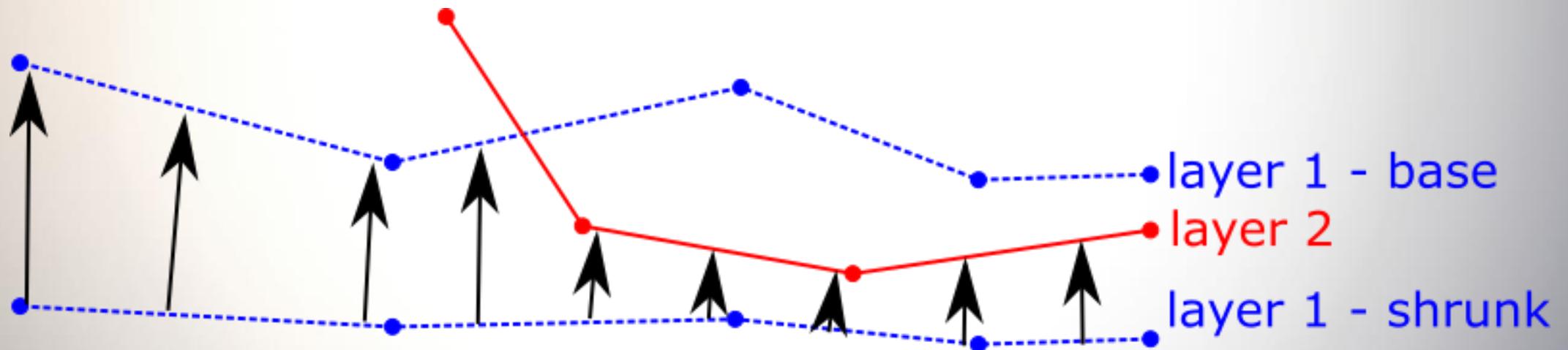
# BASE ALGORITHM

- FOR EACH TRIANGLE
  - PICK N RANDOM SAMPLES (BARYCENTRIC COORDINATES)



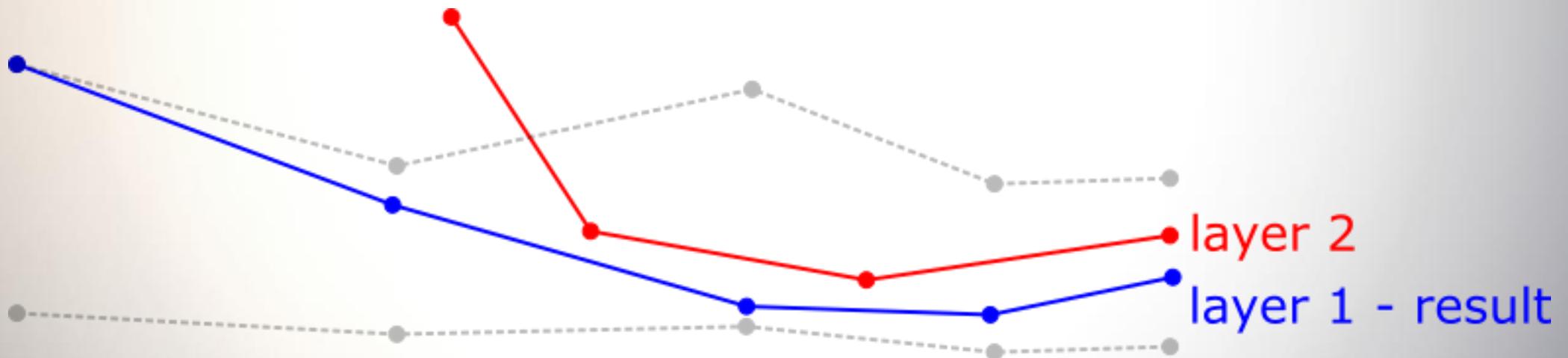
# BASE ALGORITHM

- FOR EACH TRIANGLE
  - TRACE N RAYS



# BASE ALGORITHM

- FOR EACH TRIANGLE
  - TRANSFORM INTERSECTIONS TO VERTEX WEIGHTS



# TRACE STEP DETAILS

- REALLY SIMPLE HASH-GRID
  - FAST BUILD
  - SHORT RAYS -> FAST SEARCH
- READS ALPHA MASK
  - PREPROCESSED FOR ALL MESH-TEXTURE PAIRS



# ALGORITHM INTEGRATION

- EXECUTED IN A SEPARATE THREAD
  - BACKGROUND TASK
  - TRIGGERED ON ITEM EQUIP
- USES BIND “T” POSE
- RESULTS CAN BE CACHED



# ALGORITHM EXTENSIONS

- SMOOTHING WEIGHTS
  - APPLY KERNEL ON VERTEX-EDGE GRAPH



# RESULTS - HAIR



# RESULTS - HAIR



# RESULTS - HAIR



# RESULTS - HAIR



# NOT LIMITED TO HUMANOIDS



# PERFORMANCE

- I7-4770 @ 3.4 GHZ
- SIMPLE SETUP
  - BODY, CLOTH
  - 207,312 RAYS
  - 110 MS
  - 1.88 MRAYS/S



# PERFORMANCE

- I7-4770 @ 3.4 GHZ
- ADVANCED SETUP
  - BODY, CLOTH, CHAIN
  - 417,400 RAYS
  - 365 MS
  - 1.14 MRAYS/S



# PERFORMANCE

- 17-4770 @ 3.4 GHZ
- FULL SETUP
  - BODY, CLOTH, CHAIN, PLATE, DECO
  - 770,028 RAYS
  - 879 MS
  - 0.88 MRAYS/S



# CONCLUSION



# DRAWBACKS AND FUTURE WORK

- DISPLACEMENT MAPS
- ONLY LAYERED SHAPES SUPPORTED
- DRAW CALL FOR EVERY PIECE OF CLOTHING
  - FLAW OF THE WHOLE EQUIPMENT SYSTEM
- NOT INSTANT
  - CORRECT SHAPE APPEARS AFTER A FRACTION OF SECOND
- FURTHER OPTIMIZATIONS
  - EXPLORE BVHS -> CREATE OFFLINE, REFIT ONLINE





Meet us at Gamescom in **Hall 2.1** or **Hall 10.1** and try it yourself!

