RUKHANKA

Contents

About Rukhanka

Rukhanka is an animation system for Entity Component System (ECS) for Unity Technology Stack. It depends on `Unity Entities` and `Unity Entities Graphics` packages.

Design and implementation of **Rukhanka** follows three principles:

- Trivial usage and interface
- Performance in all aspects
- Functionality and behavior are identical to `Unity Mecanim Animation System`

Simple Interface

Rukhanka has a very limited set of own user interfaces. It has no complex custom editor windows and configurable options. Everything related to animation functionality is set up using familiar Unity editors. At bake time, **Rukhanka** converts standard Unity `Animators`, `Animation Clips`, and `Skinned Mesh Renderers` into their internal structures and works with them in runtime.

Performance

Everything in **Rukhanka** is designed with performance in mind. All core systems are `ISystem` based and `Burst` compiled. Core animation calculation and state machine processing loops fully benefit from multi-core/multi-processor systems. Even debug and visualization functionality, despite that it can be completely compiled out, made `Burst` compatible as much as possible.

'Mecanim'-like behaviour

Rukhanka tries to mimic the behavior of the `Unity Mecanim Animation System`. It tries to do this during state machine processing as well as animation calculation and blending. Some parts of `Mecanim` have not been implemented yet/made similar by 100% in **Rukhanka**. Refer to *feature summary tables* for detailed information on compatibility and support features.

'Netcode for Entities' package Support

Rukhanka supports animation synchronization between server and clients in network games by working with 'Netcode for Entities' ECS library. Animation synchronization can be done by using predicted and interpolated ghosts. Client-only entities can coexist together with network-synchronized ones.

Links

- This documentation: https://docs.rukhanka.com
- Youtube channel: https://www.youtube.com/@rukhankaanimation
- Discord Support Server: https://discord.gg/AwzFjWdHfq
- Support e-mail: support@rukhanka.com

Getting Started

Prerequisites

To work with **Rukhanka Animation System** you need following:

- Unity 2022.2.15f1+
- Unity `Entities` package version 1.0.10+ (installed automatically as dependency)
- Unity `Entities.Graphics` package version 1.0.10+ (installed automatically as dependency)
- HDRP or URP as required by `Entities.Graphics` package
- [Optional] `Netcode for Entities` package for network animation synchronization support

`Humanoid` animation types not supported yet. Only `Generic` animation types can be used at this moment.

`Non-uniform` scale is not supported. Only uniform scale can be used in animations.

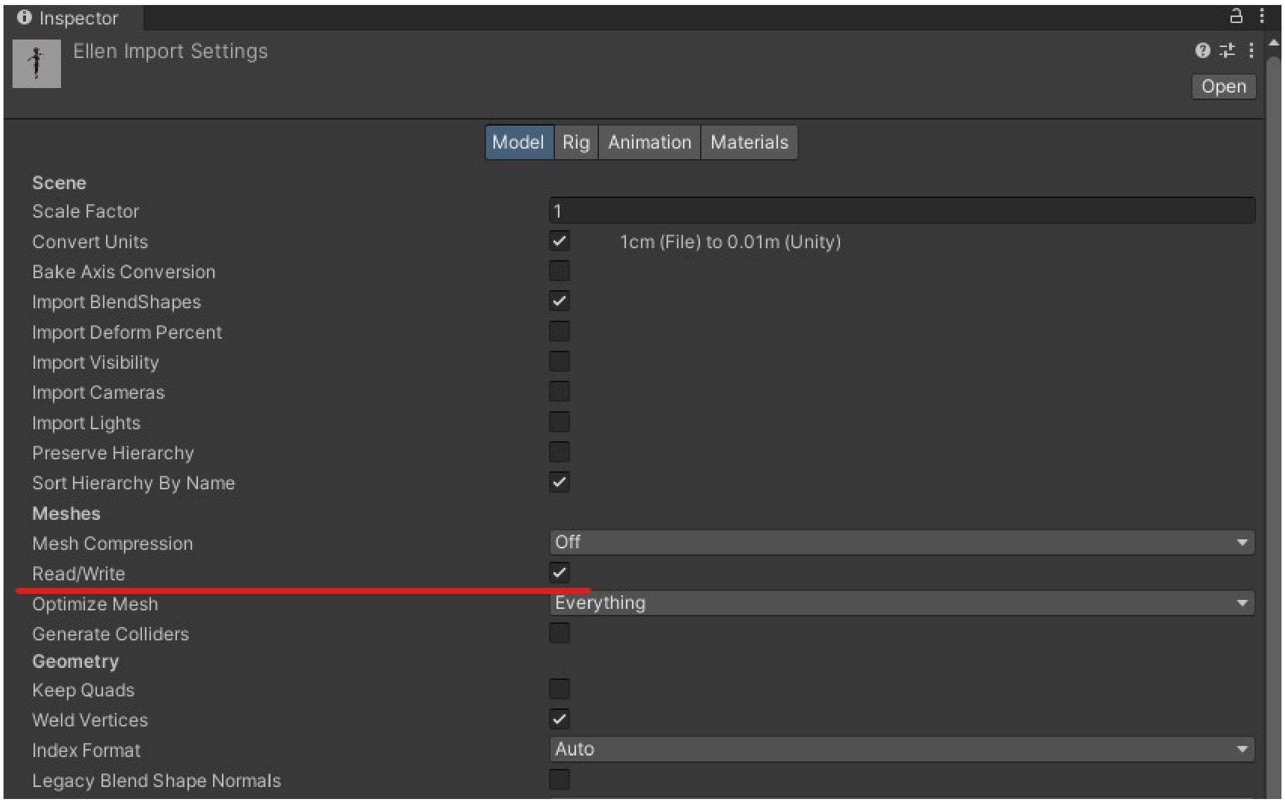
Animated Object Setup

To make animations work correctly there are some preparation setup steps are required.

Model Importer

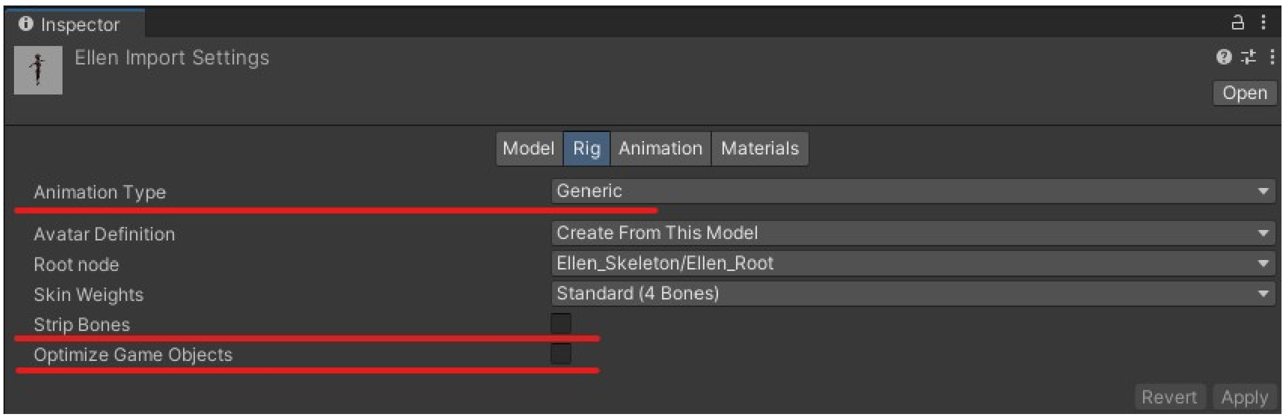
Use standard Unity model importer confuguration page to setup required model properties:

1. Model Importer Tab.
    - Enable `Read/Write` property for the mesh. This is requirement of `Deformation Subsystem` of `Entities.Graphics` package.



Scene	
Scale Factor	1
Convert Units	✓ 1cm (File) to 0.01m (Unity)
Bake Axis Conversion	
Import BlendShapes	✓
Import Deform Percent	
Import Visibility	
Import Cameras	
Import Lights	
Preserve Hierarchy	
Sort Hierarchy By Name	✓
Meshes	
Mesh Compression	Off
Read/Write	✓
Optimize Mesh	Everything
Generate Colliders	
Geometry	
Keep Quads	
Weld Vertices	✓
Index Format	Auto
Legacy Blend Shape Normals	

2. Rig Importer Tab.
    - Set `Animation Type` to `Generic`. Other types (particulary `Humanoid`) not supported yet.
    - Uncheck `Strip Bones` checkbox. **Rukhanka** need full unmodified hierarchy for own avatar setup.
    - Uncheck `Optimize Game Objects` checkbox. **Rukhanka** need all bone game objects in baking phase.


Inspector

Ellen Import Settings

Model | Rig | Animation | Materials

Animation Type: Generic

Avatar Definition: Create From This Model

Root node: Ellen_Skeleton/Ellen_Root

Skin Weights: Standard (4 Bones)

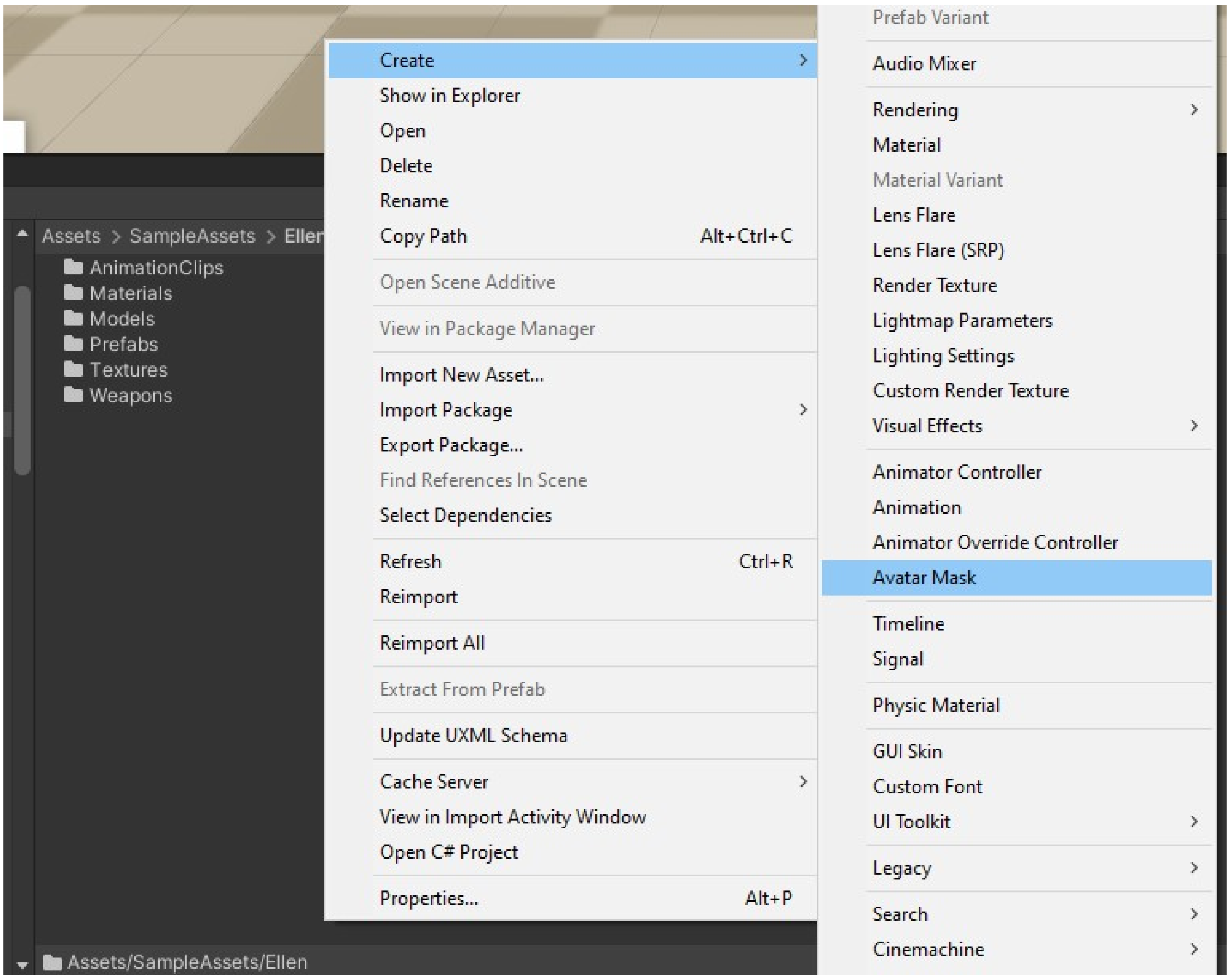
Strip Bones: ☐

Optimize Game Objects: ☐

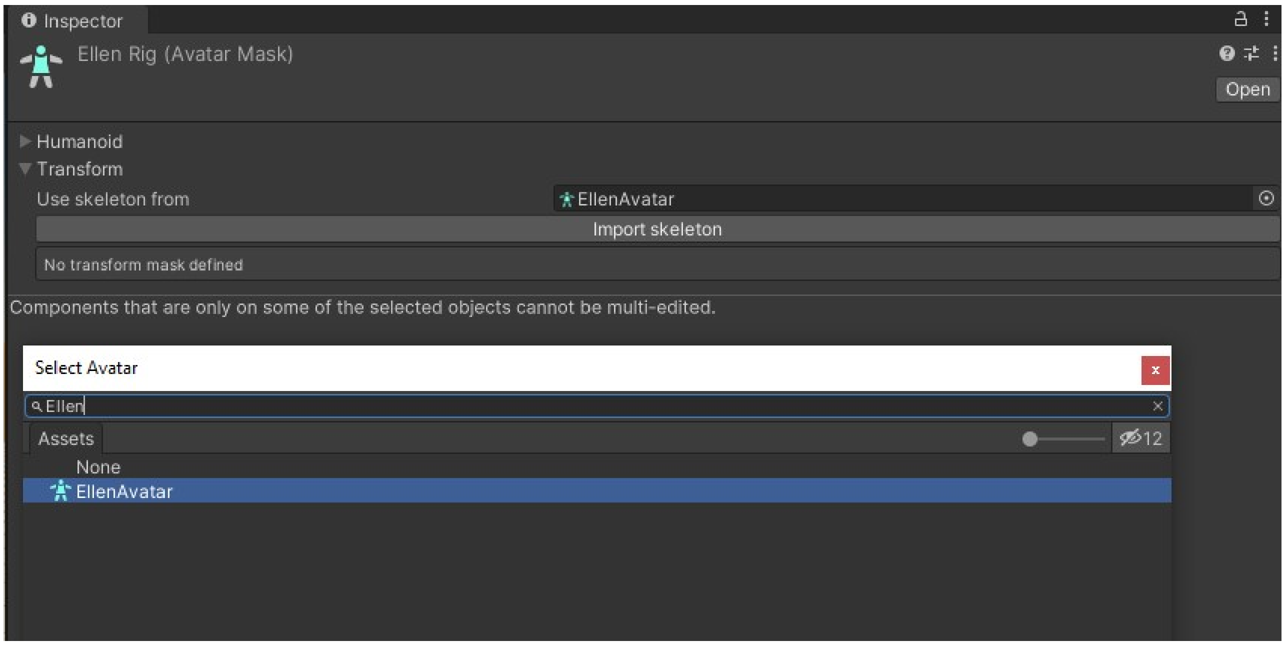
Rig Definition

Rukhanka baking systems cannot use `Unity Avatar` because of lack of required public interfaces in it. It is necessary to create own `Rig Definition` from `Unity Avatar`. **Rukhanka** uses internal Unity's `Avatar Mask` functionality to define Rig bones hierarchy. All transform data will be gathered from `GameObject` hierarchy during baking.

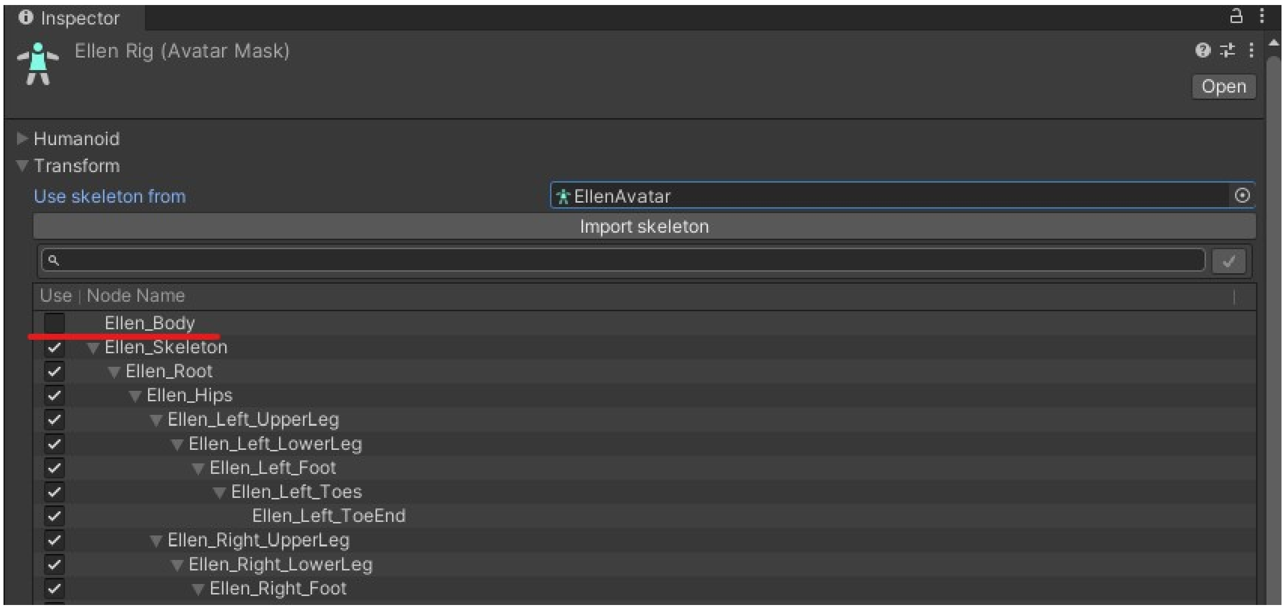
1. Create new `Avatar Mask` somwhere inside project assets directories.



2. In `Avatar Mask` inspector pick your model `Avatar` in `Transform->Use skeleton from` field.


Inspector
Ellen Rig (Avatar Mask)
Open
Humanoid
Transform
Use skeleton from EllenAvatar
Import skeleton
No transform mask defined
Components that are only on some of the selected objects cannot be multi-edited.
Select Avatar
Ellen
Assets
12
None
EllenAvatar

3. Press `Import skeleton` button to import entire avatar rig hierarchy into this `Avatar Mask`.
4. Expand all nodes and make sure that every bone is selected and meshes are not selected.


Inspector
Ellen Rig (Avatar Mask)
Open
Humanoid
Transform
Use skeleton from EllenAvatar
Import skeleton

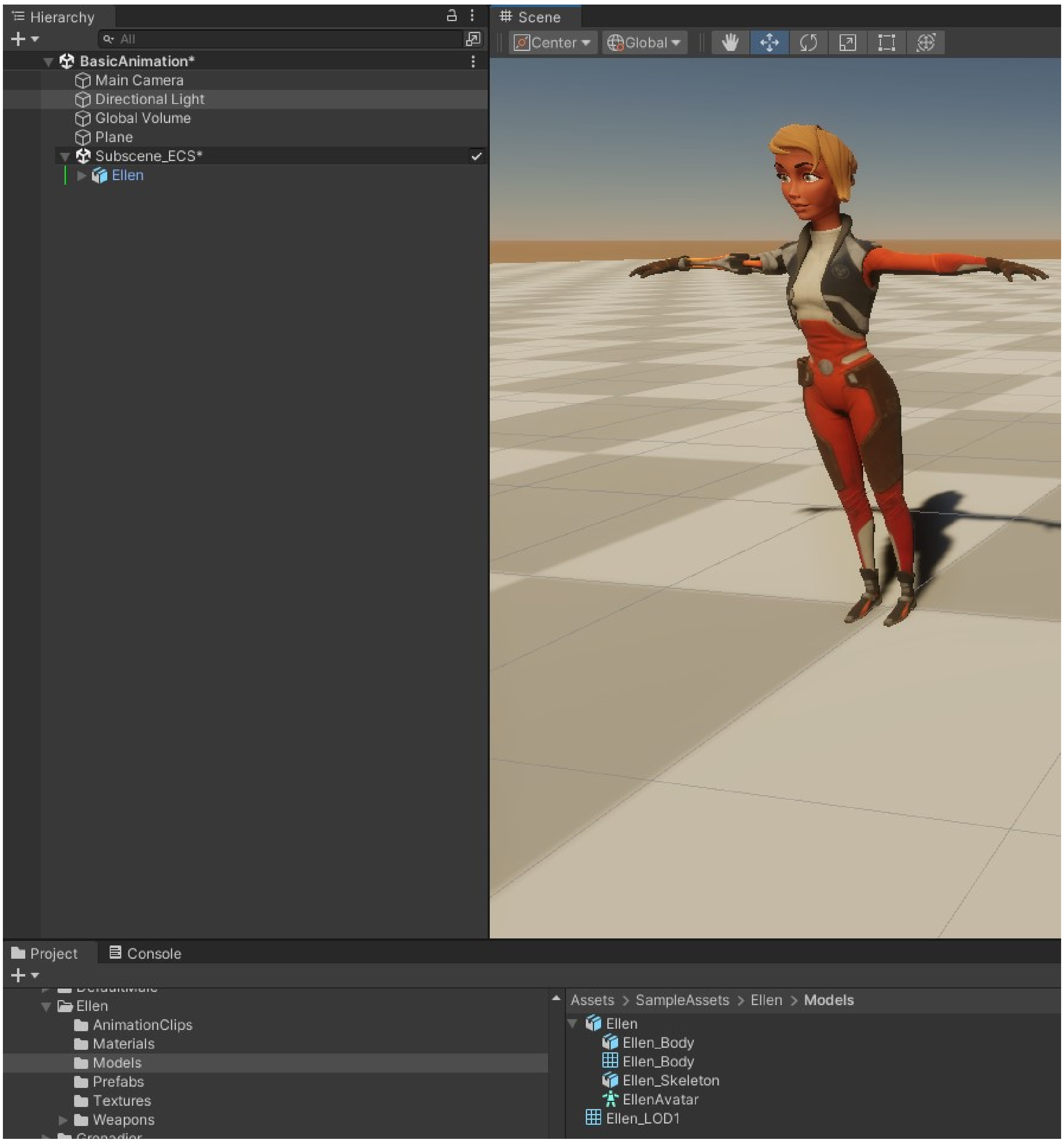
Use	Node Name
☐	Ellen_Body
✓	Ellen_Skeleton
✓	Ellen_Root
✓	Ellen_Hips
✓	Ellen_Left_UpperLeg
✓	Ellen_Left_LowerLeg
✓	Ellen_Left_Foot
✓	Ellen_Left_Toes
✓	Ellen_Left_ToeEnd
✓	Ellen_Right_UpperLeg
✓	Ellen_Right_LowerLeg
✓	Ellen_Right_Foot

5. Do not forget to rename your new `Avatar Mask` to something meaningful (like `EllenRig` in this examples) to indicate that this is not ordinary `Avatar Mask` but **Rukhanka** `Rig Definition`.

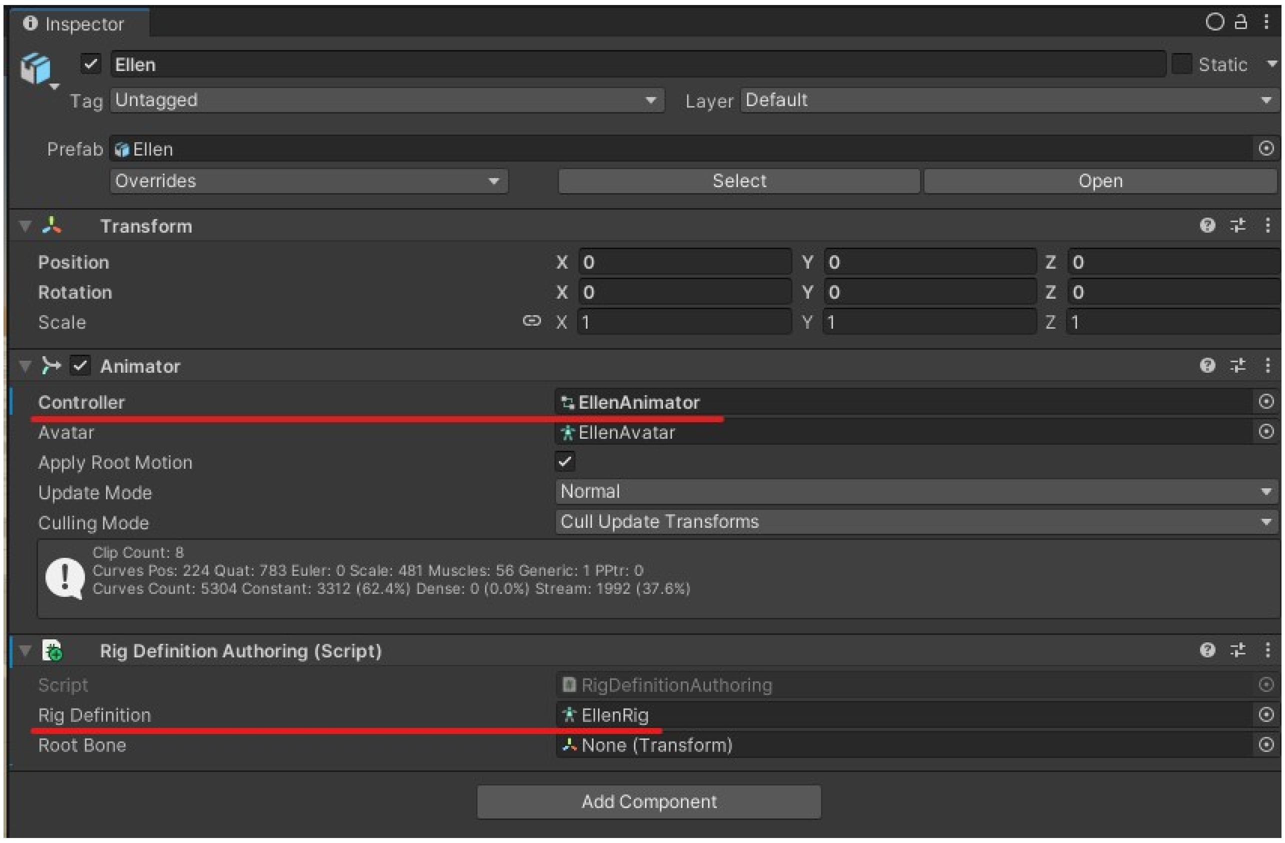
Authoring Object Setup

Final step is to create authoring `GameObject` inside `Entities` Subscene

1. Place your animated object inside `Entities` Subscene. For detailed description of this step refer Entites Package documentation.



2. Add `Rig Definition Authoring` component to newly created object.
3. Place `Rig Definition` created previously in `Rig Definition` slot of `Rig Definition Authoring` component.
4. Create standard `Animator Controller` and fill it as you wish (one state with one animation will be good start).


Inspector

Ellen — Static

Tag: Untagged — Layer: Default

Prefab: Ellen

Overrides — Select — Open

Transform

Position	X 0	Y 0	Z 0
Rotation	X 0	Y 0	Z 0
Scale	X 1	Y 1	Z 1

Animator

Controller	EllenAnimator
Avatar	EllenAvatar
Apply Root Motion	✓
Update Mode	Normal
Culling Mode	Cull Update Transforms

```
Clip Count: 8
Curves Pos: 224 Quat: 783 Euler: 0 Scale: 481 Muscles: 56 Generic: 1 PPtr: 0
Curves Count: 5304 Constant: 3312 (62.4%) Dense: 0 (0.0%) Stream: 1992 (37.6%)
```

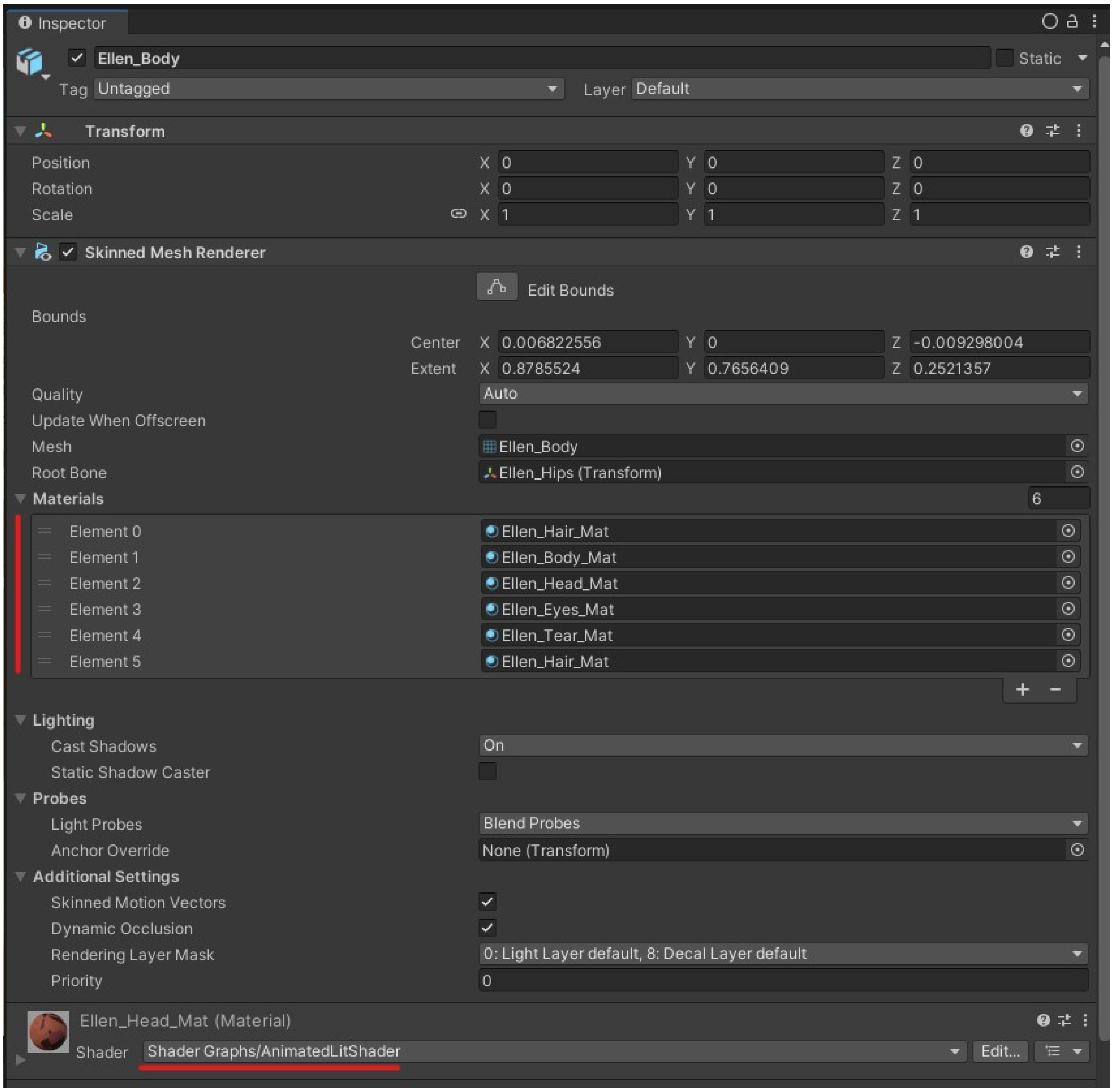
Rig Definition Authoring (Script)

Script	RigDefinitionAuthoring
Rig Definition	EllenRig
Root Bone	None (Transform)

Add Component

Shaders And Materials

Rukhanka does not render animated objects. It only prepares skin matrices for skinned meshes that are entirely managed by `Entities.Graphics` package. To be able to render deformed meshes correctly it is required to make `Entities.Graphics` compatible deformation-aware shader. Read carefully Mesh deformations section of `Entities.Graphics` package documentation. Make compatible shader using `Unity Shader Graph` or `Amplify Shader Editor` as described in the Shaders with Deformation page of this manual. Make and assign all required materials to your animated model.


Inspector

Ellen_Body — Static
Tag: Untagged — Layer: Default

Transform

	X	Y	Z
Position	0	0	0
Rotation	0	0	0
Scale	1	1	1

Skinned Mesh Renderer

Edit Bounds

Bounds

	X	Y	Z
Center	0.006822556	0	-0.009298004
Extent	0.8785524	0.7656409	0.2521357

Quality	Auto
Update When Offscreen	
Mesh	Ellen_Body
Root Bone	Ellen_Hips (Transform)
Materials	6
Element 0	Ellen_Hair_Mat
Element 1	Ellen_Body_Mat
Element 2	Ellen_Head_Mat
Element 3	Ellen_Eyes_Mat
Element 4	Ellen_Tear_Mat
Element 5	Ellen_Hair_Mat
Lighting	
Cast Shadows	On
Static Shadow Caster	
Probes	
Light Probes	Blend Probes
Anchor Override	None (Transform)
Additional Settings	
Skinned Motion Vectors	✓
Dynamic Occlusion	✓
Rendering Layer Mask	0: Light Layer default, 8: Decal Layer default
Priority	0

Ellen_Head_Mat (Material)
Shader: Shader Graphs/AnimatedLitShader — Edit...

End Of Setup Process

That's all needed to make **Rukhanka** be able to convert `Animator Controller`, all required `Animations` and own `Rig Definition` into internal structures. After that runtime systems will simulate state machine behaviour and play requred animations.

IMPORTANT: There is not 100% Unity's `Mecanim` feature support. Please consult Feature Support Tables for complete information.

Here is video version of the entire *Getting Started* process

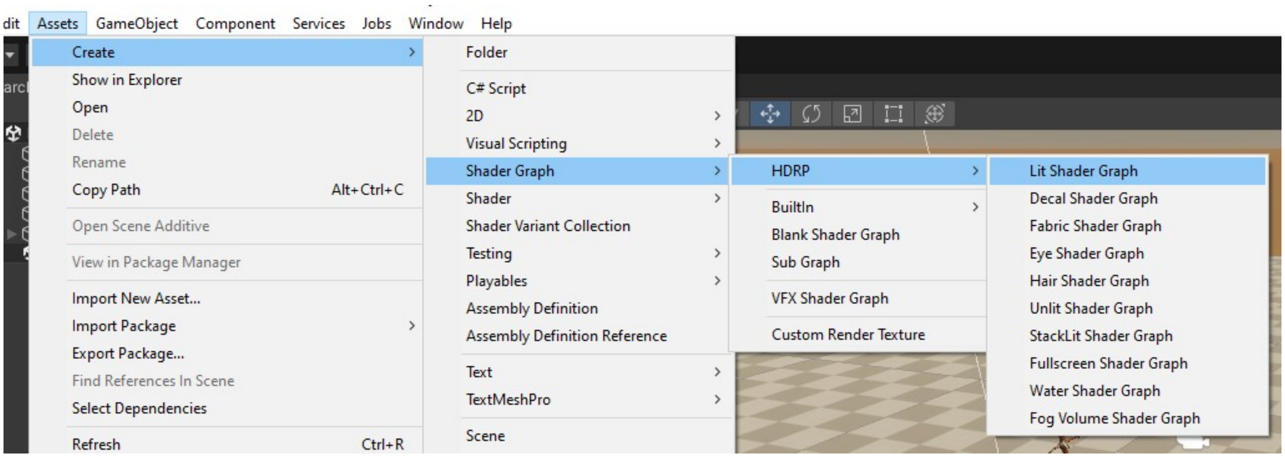
Shaders with Deformations

For the correct rendering of skinned meshes deformed by **Rukhanka**, an ECS deformation-aware shader should be created. To make this task `Unity Shader Graph` or `Amplify Shader Editor` tool can be used.

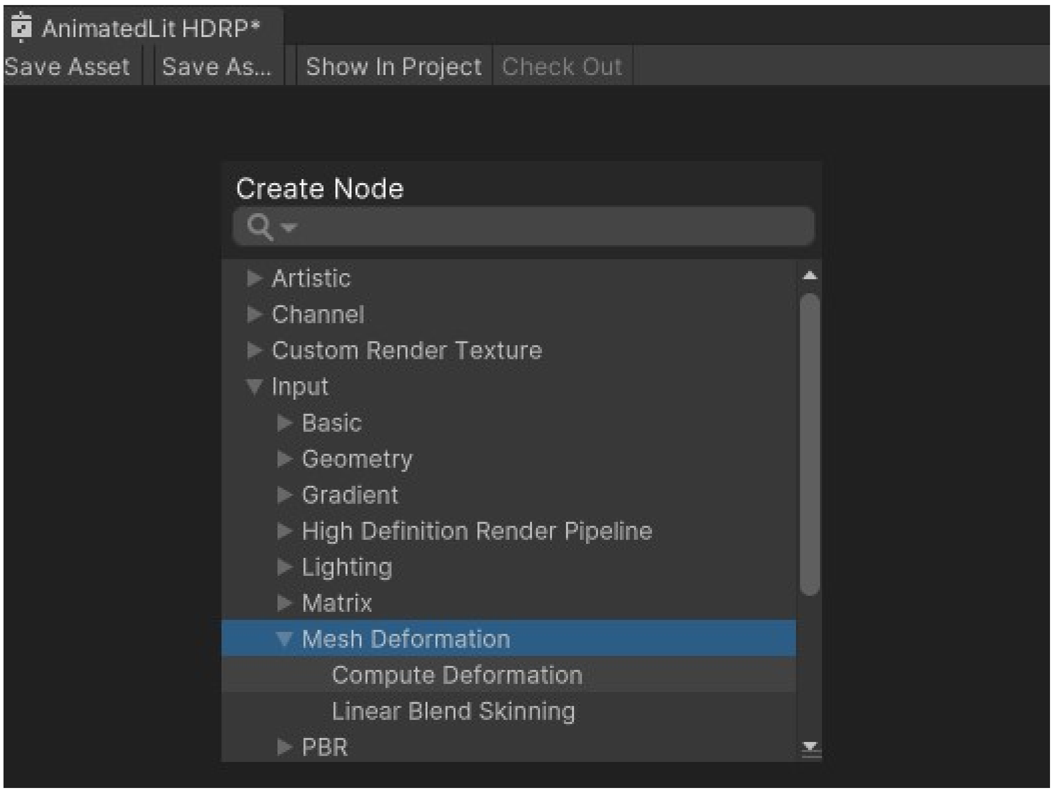
Unity Shader Graph

Creating deformation-compatible shaders using `Unity Shader Graph` is straightforward. The whole process is described in detail in mesh deformation section of official `Entities Graphics` documentation. The process consists of several simple steps:

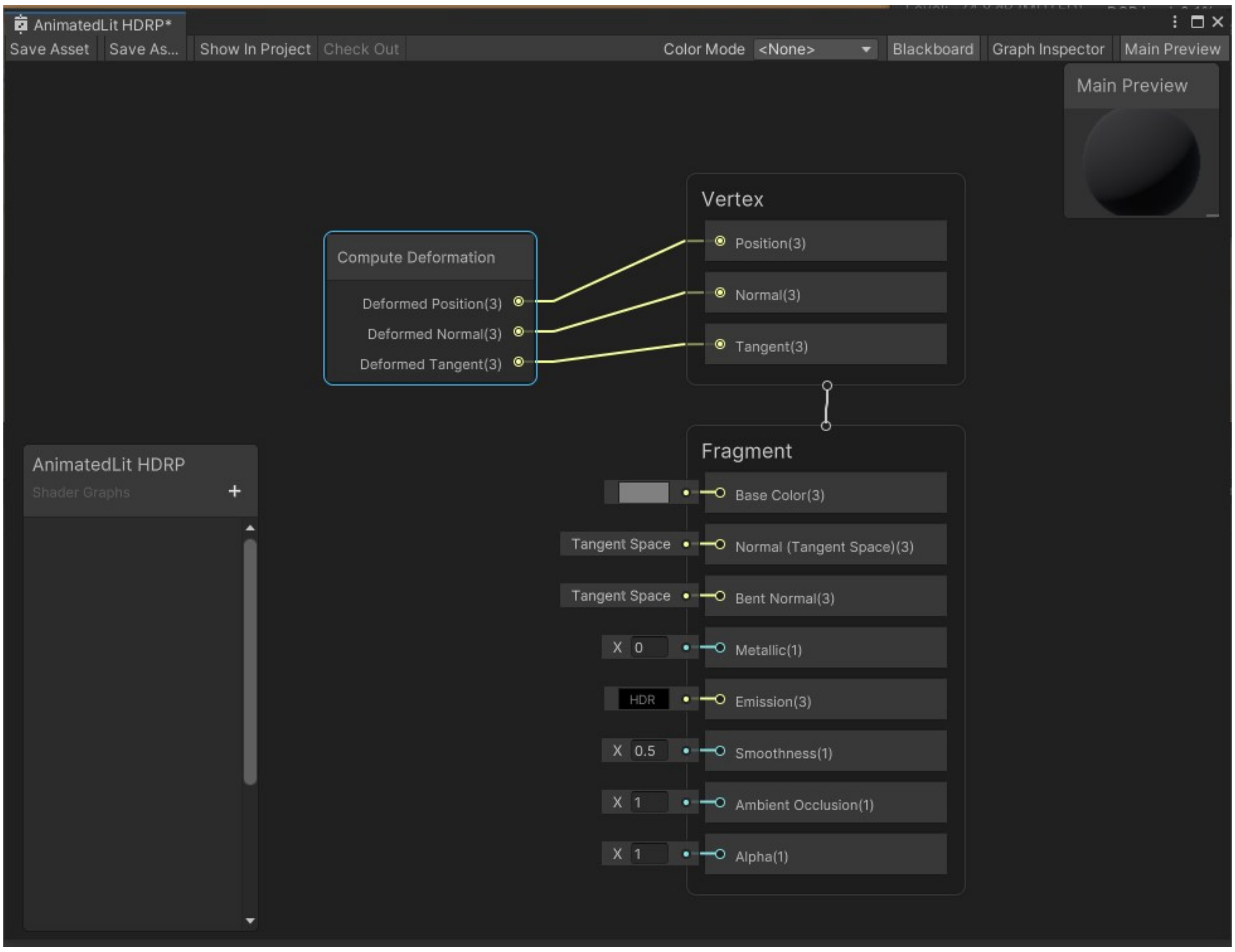
1. Create a shader graph (URP or HDRP depending on the render pipeline you are using) and open it for editing.



2. Add the `Compute Deformation` node to the Shader Graph.



3. Connect position, normal, and tangent output ports for the `Compute Deformation` node to the corresponding input ports of the master node.

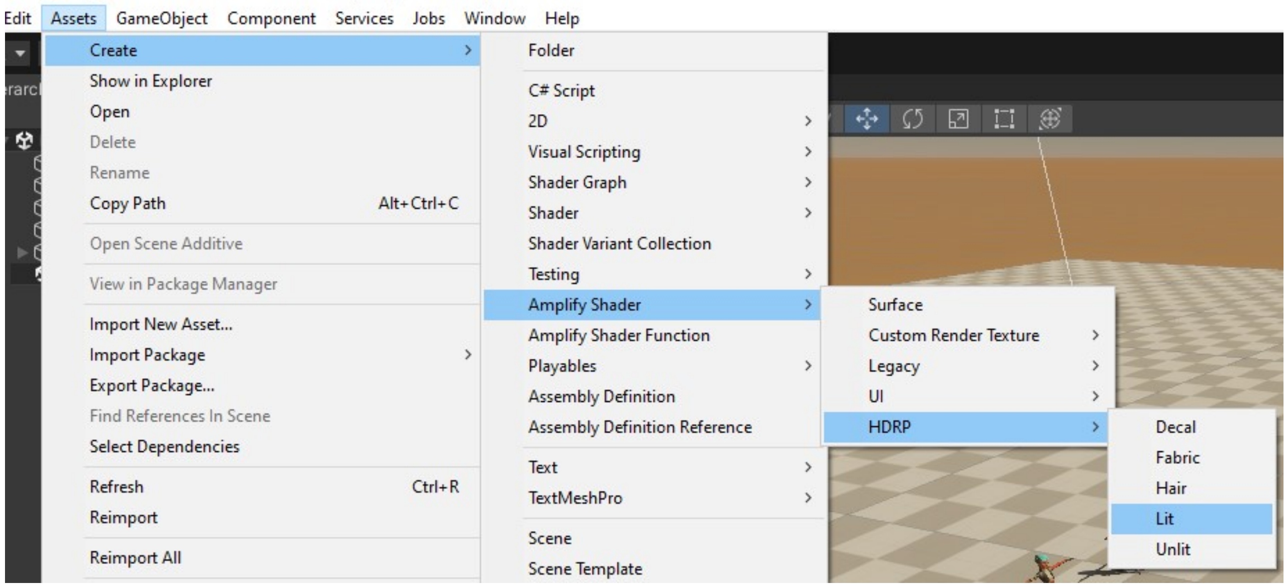


4. Save and assign this newly created shader to the materials of skinned mesh renderers.

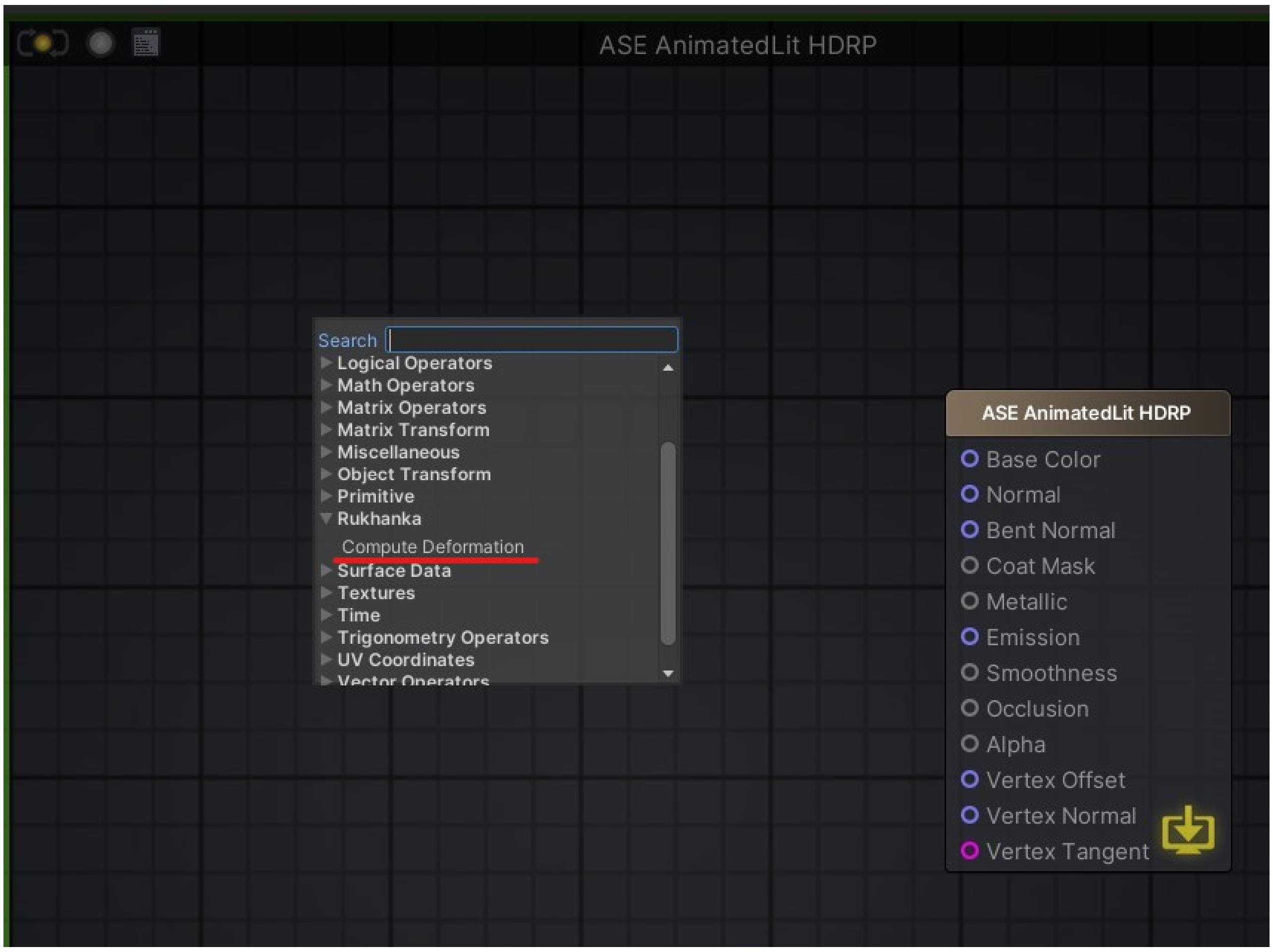
Amplify Shader Editor

`Amplify Shader Editor` tool has no `Entities.Graphics` compute deformation support out of the box, but **Rukhanka** adds necessary functionality to it. The process of creating deformation aware shader in `Amplify Shader Editor` is also simple:

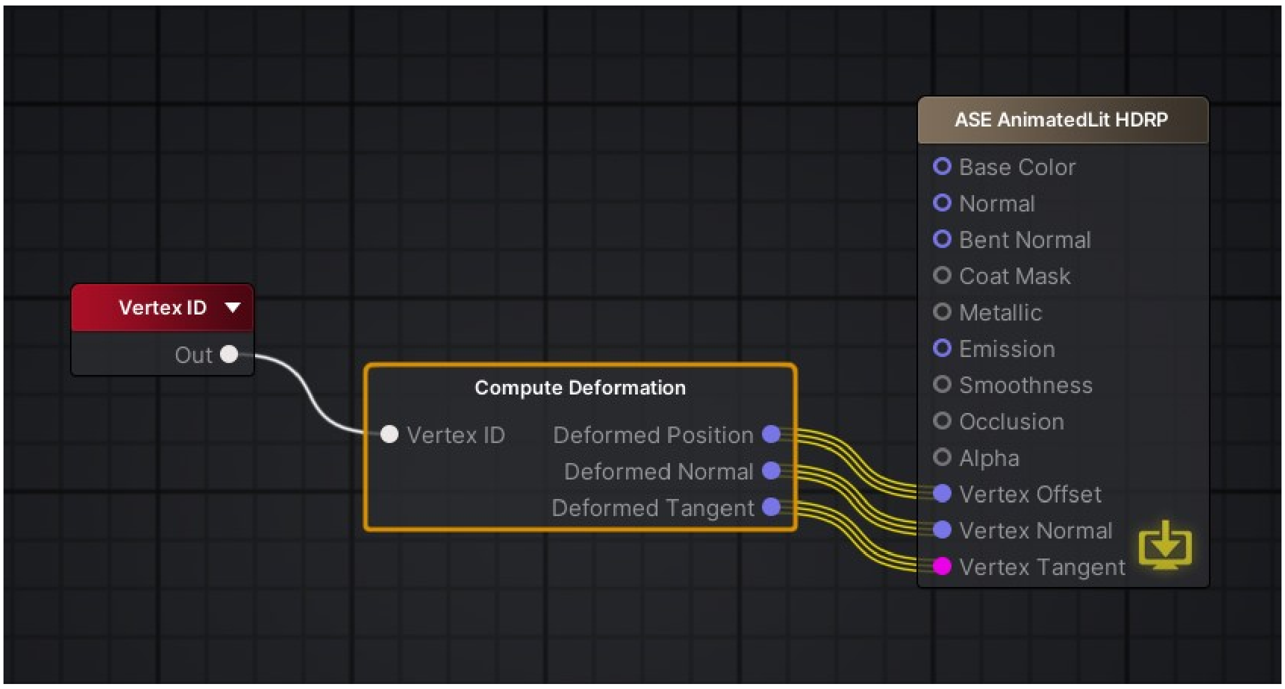
1. Create `Amplify Shader` and open it for editing.



2. Open the `Add Node` dialog (`Space` or `Right Click`) and add the `Rukhanka->Compute Deformation` node.



3. Add `Vertex Data->Vertex ID` node.
4. Connect the `Out` port of the `Vertex ID` node with the `Vertex ID` port of the `Compute Deformation` node.
5. Connect the `Deformed Position` port of the `Compute Deformation` node with the `Vertex Offset` port of the shader master node.
6. Connect the `Deformed Normal` port of the `Compute Deformation` node with the `Vertex Normal` port of the shader master node.
7. Connect the `Deformed Tangent` port of the `Compute Deformation` node with the `Vertex Tangent` port of the shader master node.



8. Select the shader master node and enable the `DOTS Instancing` option, and set `Vertex Position` to `Absolute`.

Animator Parameters

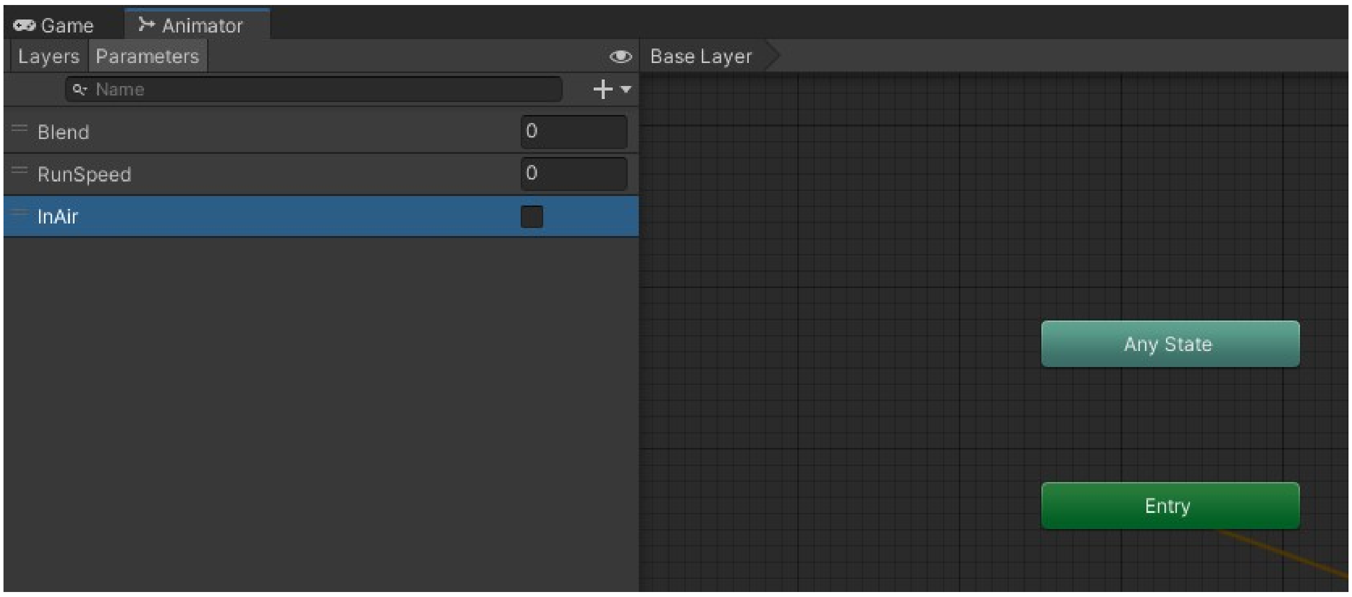
Direct Buffer Indexing

Rukhanka made `DynamicBuffer` for all animator parameters so the user can control its values from the code.

Basically, only `DynamicBuffer` with animator parameters is needed to access and manipulate parameter values. This is shown in the following code snippet:

```
[BurstCompile]
partial struct ProcessInputJob: IJobEntity
{
    void Execute(ref DynamicBuffer<AnimatorControllerParameterComponent> allParams)
    {
        var someParameter = allParams[0];
        // Increment parameter
        someParameter.FloatValue += 1.0f;
        // Put value back in the array
        allParams[0] = someParameter;
        ...
    }
}
```

This approach has only one advantage: access speed. Animator parameters are ordered in a way how they are defined in Unity's `Animator` from top to bottom. For example, in `Animator` parameters given in the next picture, there are three parameters: [0] - "Blend", [1] - "Run Speed", [2] - "InAir":



Perfect Hash Table

Accessing parameters by index has no name-value relationship. Any animator parameter reordering in `Animator Controller` will break the game logic code. So there is a better solution: accessing using a hash table. **Rukhanka** prepares `Perfect Hash Table` for a list of parameters during the baking stage. A perfect hash table is a hash table that has an unambiguous 'parameter name' -> 'array index' relationship. It is faster than ordinary hash tables and also has O(1) access complexity.

To simplify access to the parameters using a hash table, the helper class named `FastAnimatorParameter` is introduced. Follow these steps to access the animator parameter by name and in a very performant way:

- Define required `FastAnimatorParameters` as, for example, system private fields:

```
public partial class PlayerControllerSystem: SystemBase
{
    FastAnimatorParameter blendParam  = new FastAnimatorParameter("Blend");
    FastAnimatorParameter runSpeedParam  = new FastAnimatorParameter("RunSpeed");
```

```
        FastAnimatorParameter inAirParam  = new FastAnimatorParameter("InAir");
        ...
    }
```

- Pass prepared `FastAnimatorParameters` in the job:

```
protected override void OnUpdate()
{
    var processInputJob = new ProcessInputJob()
    {
        blendParam = this.blendParam,
        runSpeedParam = this.runSpeedParam,
        inAirParam = this.inAirParam
    };

    ...
}
```

- Query `AnimatorControllerParameterIndexTableComponent` component (it is the perfect hash table for a set of animator parameters) and use the `FastAnimatorParameter` methods to access parameter value:

```
[BurstCompile]
partial struct ProcessInputJob: IJobEntity
{
    public FastAnimatorParameter blendParam;
    public FastAnimatorParameter runSpeedParam;
    public FastAnimatorParameter inAirParam;

    void Execute(in AnimatorControllerParameterIndexTableComponent paramIndexTable, ref DynamicBuffe
    {
        var t = paramIndexTable.seedTable;

        blendParam.GetRuntimeParameterData(t, allParams, out var blendParamvalue);
        blendParam.SetRuntimeParameterData(t, allParams, new ParameterValue() { floatValue = blendPa
        inAirParam.SetRuntimeParameterData(t, allParams, new ParameterValue() { boolValue = true } )
    }
}
```

Animator Parameters Aspect

To further simplify animator parameter access there is `AnimatorParametersAspect` is introduced. It has several methods for convenient parameter data access:

```
[BurstCompile]
partial struct ProcessInputJob: IJobEntity
{
    public InputStateData inputData;

    public FastAnimatorParameter floatParam;
    public FastAnimatorParameter intParam;
    public FastAnimatorParameter triggerParam;

    void Execute(ref AnimatorParametersAspect paramAspect)
    {
        paramAspect.SetParameterValue(floatParam, 2.2f);
        paramAspect.SetParameterValue(intParam, 42);
        paramAspect.SetParameterValue(boolParam, true);

        var floatValue = paramAspect.GetFloatParameter(floatParam);
        var boolValue = paramAspect.GetFloatParameter(boolParam);
    }
}
```

Some functions of `AnimatorParametersAspect` accept `FixedString` with parameter names. Those variants are slower than with `FastAnimatorParameter` and created mostly for easiness of quick prototyping and should not be used in final high performance code.

Entity Components

Rukhanka conceptually consists of two main modules: * Animator controller * Animation processor

Each module has its own baker system that prepares data for it by converting appropriate authoring components (Unity Animator, Unity Skinned Mesh Renderer, and Unity Animations)

Animator Controller System

The main function of the controller is advancing the animation state machine with time and preparing required animations for the current state and transitions. The animator controller system processes entities with the `AnimatorControllerLayerComponen` component array. Each element in this array represents separate animation layer as specified in Unity Animator.

```
public struct AnimatorControllerLayerComponent: IBufferElementData, IEnableableComponent
{
    ...
}
```

`AnimatorControllerLayerComponent` is inherit IEnableableComponent so can be enabled and disabled. If disabled, the state machine of this owning entity will not be processed, and the model stops its animations (pose will be paused). After enabling the state machine will continue from the moment of pause.

During state machine processing, all prepared animations will be arranged in form of an array of `AnimationToProcessComponent` components.

```
public struct AnimationToProcessComponent: IBufferElementData
{
    ...
}
```

Animation Process System

This system reads the `AnimationToProcessComponent` array, samples animations at specified times and blends results according to required blend rules. The animated entity is defined as `RigDefinitionComponent`:

```
public struct RigDefinitionComponent: IComponentData, IEnableableComponent
{
    ...
}
```

This component is also inherited from `IEnableableComponent` and can be enabled or disabled accordingly. In disabled state, all animations for an entity are not processed, but the corresponding state machine will continue its work and still provides the rig with updated animation data. After enabling `RigDefinitionComponent`, animations will jump to the actual state machine animation state.

Animator State Query

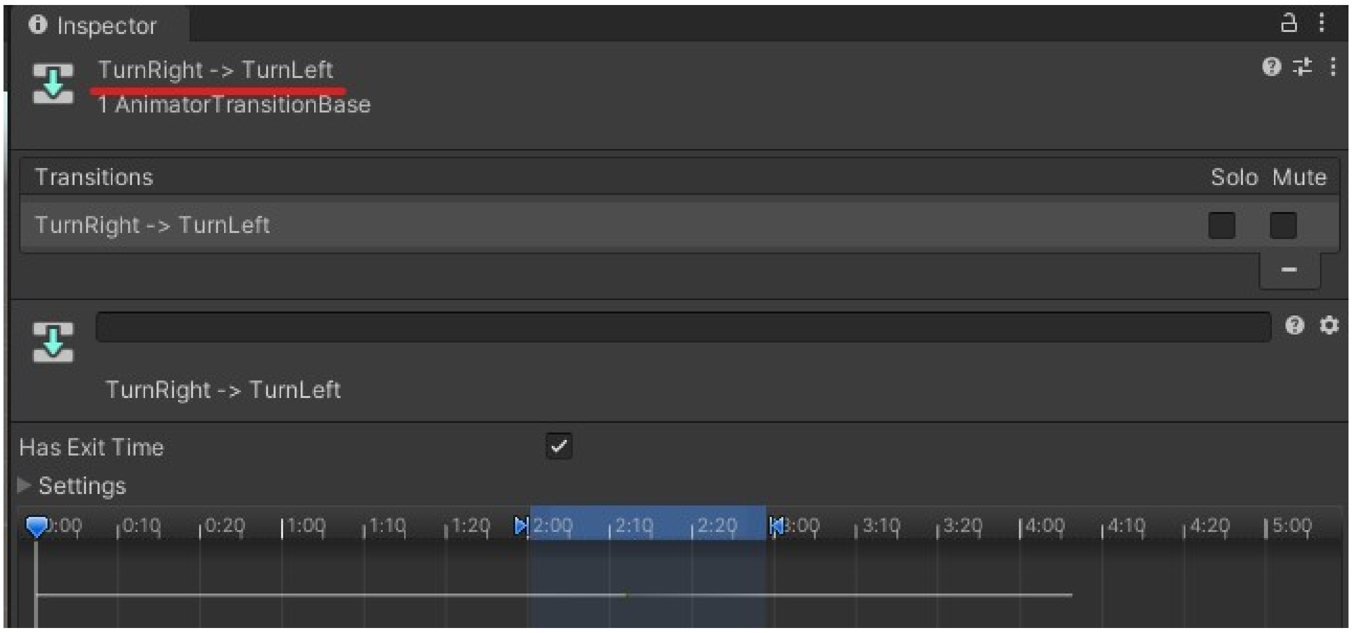
It is possible to query the runtime animator's internal state using the `AnimatorStateQueryAspect` aspect. State and transition data returned by this aspect contain a hash of state/transition respectively and normalized time (how much time controller is in this state/transition). To find out the required state, the hash value of it must be calculated upfront. This should be done by constructing `FixedStringName` with a state name. For example, a state with the name "Idle Random" can be used as follows:

```
var stateNameFull = new FixedStringName("Idle Random");
```

Hash code can be obtained from this string by calling `CalculateHash32()` member function:

```
var stateHash = stateNameFull.CalculateHash32();
```

For transitions, the process is the same:



```
var transitionName = new FixedStringName("Turn Right -> Turn Left");
var transitionHash = transitionName.CalculateHash32();
```

Here is a usage example of `AnimatorStateQueryAspect`:

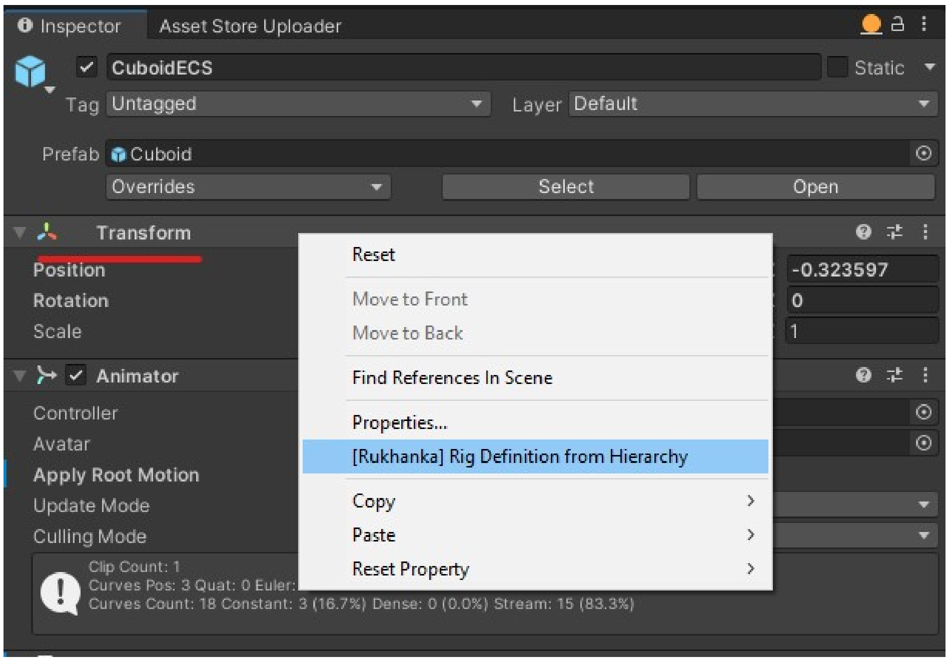
```
public partial struct MySystem : ISystem
{
    uint myStateHash, myTransitionHash;

    public void OnStart(ref SystemState state)
    {
        myStateHash = new FixedStringName("State Name").CalculateHash32();
        myTransitionHash = new FixedStringName("State Name -> State Other Name").CalculateHash32();
    }

    public void OnUpdate(ref SystemState state)
    {
        foreach (var animatorState in SystemAPI.Query<AnimatorStateQueryAspect>())
        {
            // Specify required layer index of animator.
            var layerIndex = 0;

            // Get animator current state
            var runtimeState = animatorState.GetLayerCurrentStateInfo(layerIndex);

            // Use received RuntimeStateInfo structure to access to the current state hash, and normaliz
            if (runtimeState.hash == myStateHash)
            {
                //  Do something...
            }

            //  Get current transition
            var transitionState = animatorState.GetLayerCurrentTransitionInfo(layerIndex);
            if (myTransitionHash === transitionState.hash)
            {
                //  Do something...
            }
        }
    }
}
```

If the `RUKHANKA_DEBUG_INFO` script symbol is defined in the project, `RuntimeTransitionInfo` and `RuntimeStateInfo` structures will contain a `name` field with a transition/state symbolic name in it. There is an example named `Animator State Query` in **Rukhanka** samples. It shows described above features.

Non-skinned Mesh Animation

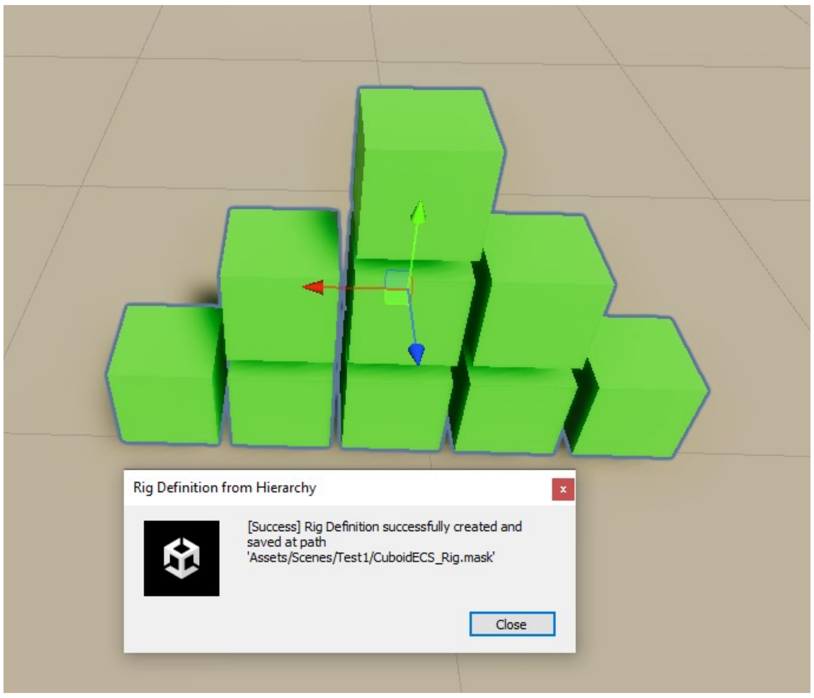
Rukhanka can animate arbitrary Entity hierarchy. The process is essentially the same as for ordinary skinned meshes:

- Create an `Animator` and define animations in it.
- Place an object on subscene and add the `Rig Definition Authoring` Unity component to it.
- Use special **Rukhanka**'s function to make `Rig Definition` from the `GameObject` hierarchy. Right-click on the hierarchy root `Transform` component caption, and choose the `[Rukhanka] Rig Definition from Hierarchy` option:



Clip Count: 1
Curves Pos: 3 Quat: 0 Euler:
Curves Count: 18 Constant: 3 (16.7%) Dense: 0 (0.0%) Stream: 15 (83.3%)

- Rig Definition `Avatar Mask` asset will be created in the current project directory:



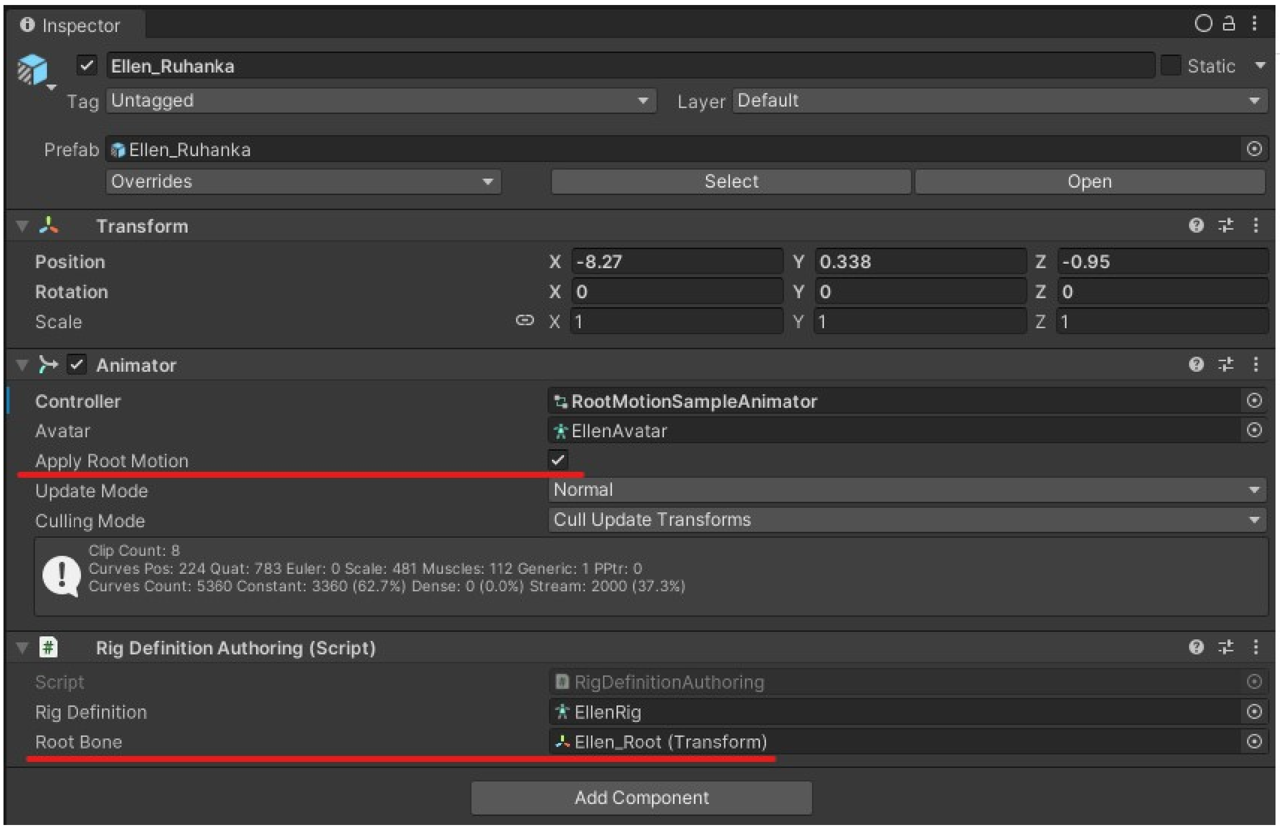
[Success] Rig Definition successfully created and saved at path 'Assets/Scenes/Test1/CuboidECS_Rig.mask'

- Assign newly created `Rig Definition` into the `Rig Definition` field of the `Rig Definition Authoring` component.
- Add Unity `Animator` component, and assign the `Animator` state machine to it.

Root Motion

Rukhanka has limited root motion support. Follow these steps to enable root motion for your model:

- Set the `Apply Root Motion` checkbox in the Unity `Animator` component:



Inspector
Ellen_Ruhanka
Static
Tag Untagged
Layer Default
Prefab Ellen_Ruhanka
Overrides
Select
Open

Transform
Position X -8.27 Y 0.338 Z -0.95
Rotation X 0 Y 0 Z 0
Scale X 1 Y 1 Z 1

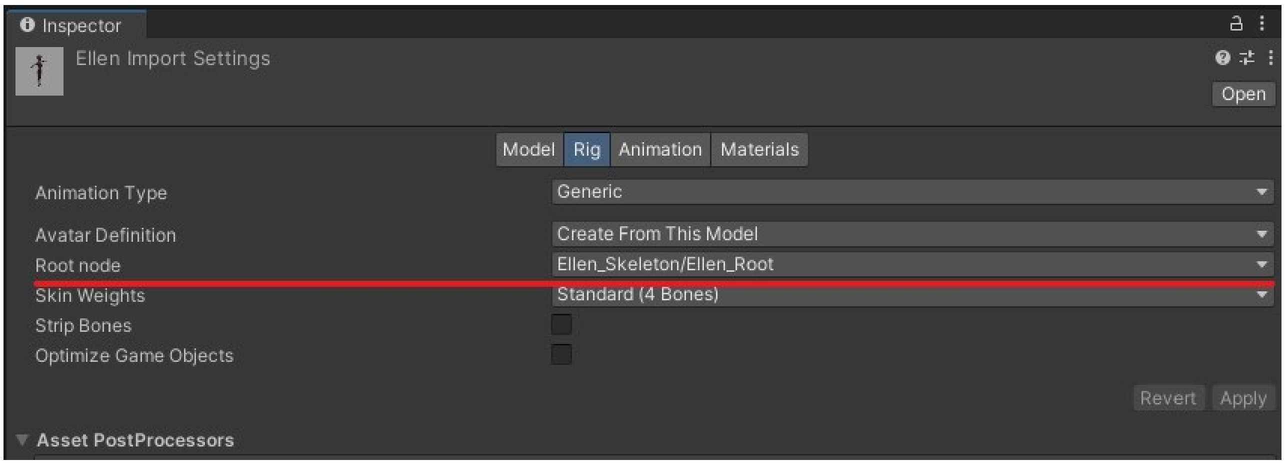
Animator
Controller RootMotionSampleAnimator
Avatar EllenAvatar
Apply Root Motion ✓
Update Mode Normal
Culling Mode Cull Update Transforms

```
Clip Count: 8
Curves Pos: 224 Quat: 783 Euler: 0 Scale: 481 Muscles: 112 Generic: 1 PPtr: 0
Curves Count: 5360 Constant: 3360 (62.7%) Dense: 0 (0.0%) Stream: 2000 (37.3%)
```

Rig Definition Authoring (Script)
Script RigDefinitionAuthoring
Rig Definition EllenRig
Root Bone Ellen_Root (Transform)

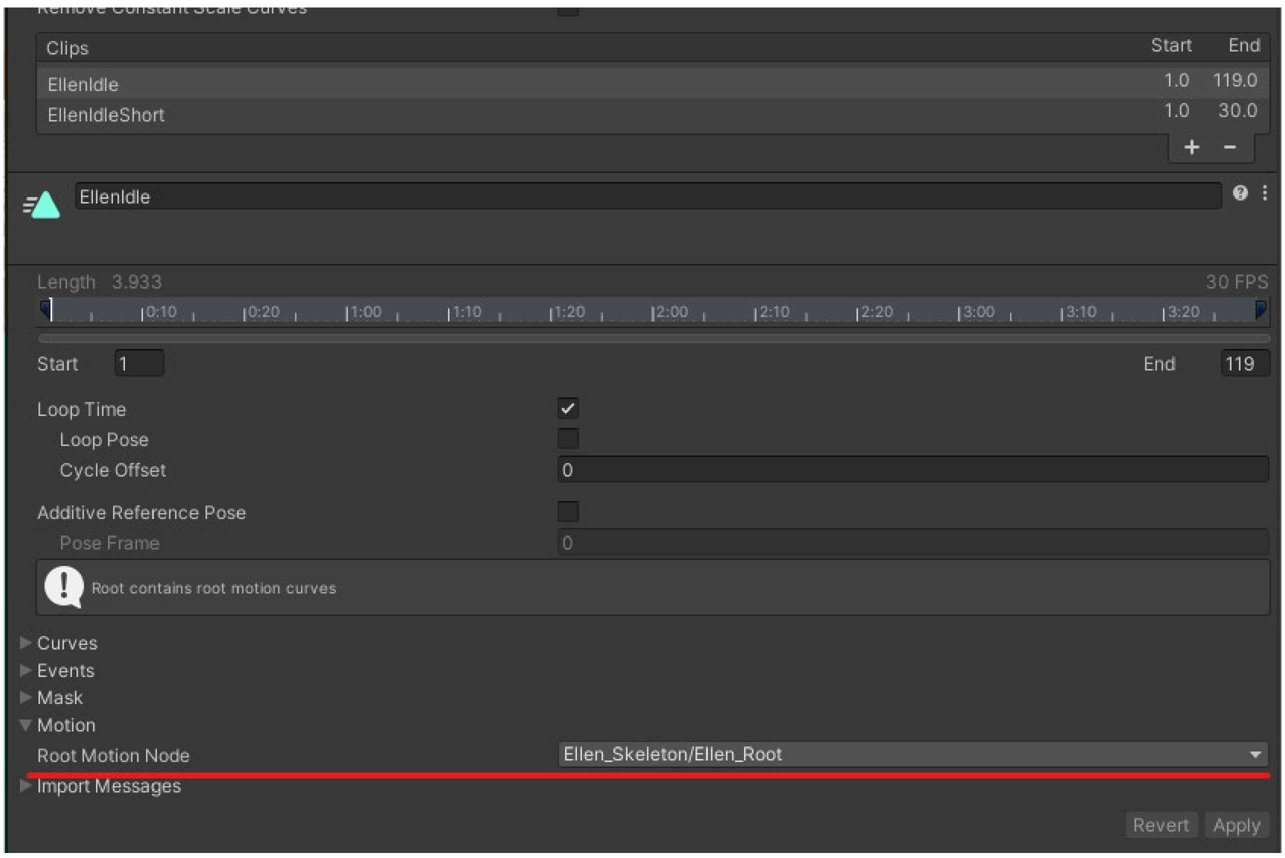
Add Component

- Set the `Root Bone` field in the `Rig Definition Authoring` component exactly the same as in the Unity model `Rig` importer configuration:



Inspector
Ellen Import Settings
Open
Model Rig Animation Materials
Animation Type Generic
Avatar Definition Create From This Model
Root node Ellen_Skeleton/Ellen_Root
Skin Weights Standard (4 Bones)
Strip Bones
Optimize Game Objects
Revert Apply
Asset PostProcessors

- Animations used in the root motion process should have a generic `Root Motion Node` defined. That node will drive animated entity position and rotation:


Clips | Start | End
EllenIdle 1.0 119.0
EllenIdleShort 1.0 30.0

EllenIdle

Length 3.933 30 FPS

Start 1 End 119

Loop Time ✓
Loop Pose
Cycle Offset 0

Additive Reference Pose
Pose Frame 0

Root contains root motion curves

Curves
Events
Mask
Motion
Root Motion Node Ellen_Skeleton/Ellen_Root
Import Messages

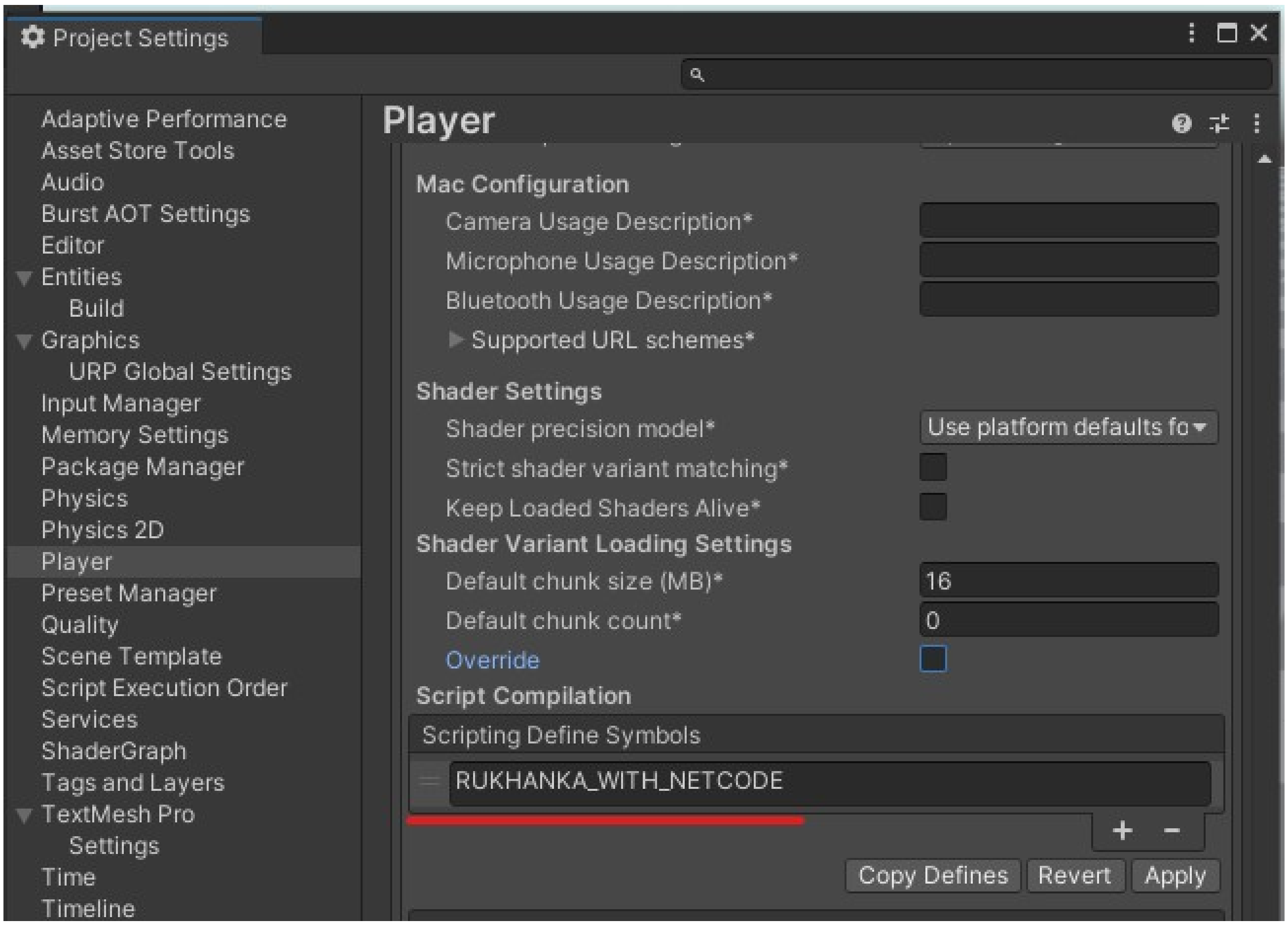
IMPORTANT: Root curves ('Root T' and 'Root Q' animation curves) are not supported yet.

User Curves

Rukhanka has user curves support. These curves can drive animator parameters exactly as Unity `Mekanim` does. Specify the user animation curve exactly as described in documentation. Make sure its name is the same as one of your animator controller parameters. **Rukhanka** will process these curves and writes the current value to the corresponding parameter component data.

Working with 'Netcode'

Rukhanka has full `Unity Netcode for Entities` package support. Network animation synchronization is available for predicted and interpolated ghosts. By default, **Rukhanka** is a client-only library. This means that it exists only in the client entity world. No data replication from server to clients is performed by the `Netcode` package. For configuring **Rukhanka** to be able to synchronize the state of animated entities over the network `RUKHANKA_WITH_NETCODE` script symbol should be defined in project settings.



Project Settings — Player

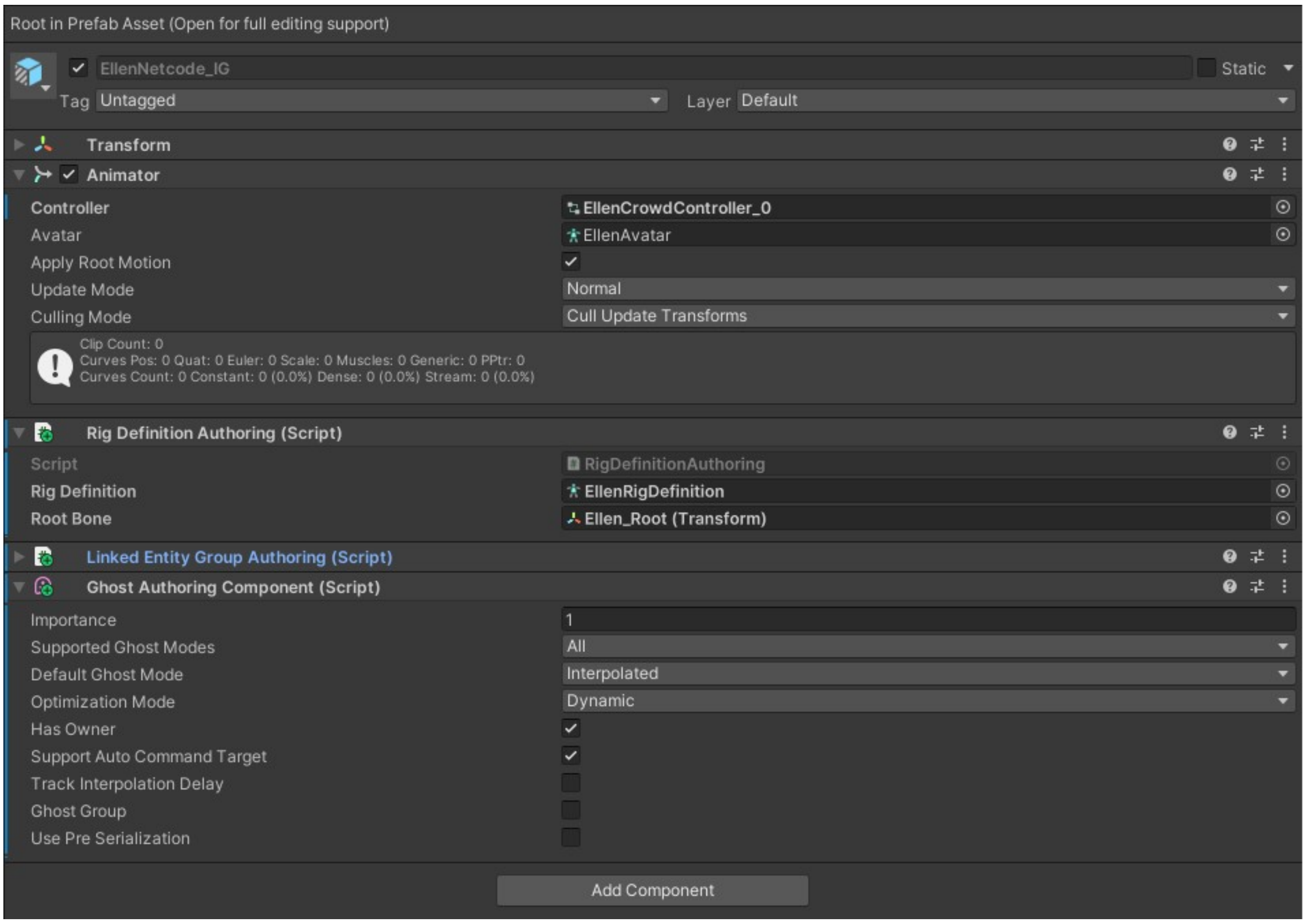
Mac Configuration
- Camera Usage Description*
- Microphone Usage Description*
- Bluetooth Usage Description*
- Supported URL schemes*

Shader Settings
- Shader precision model*: Use platform defaults fo
- Strict shader variant matching*
- Keep Loaded Shaders Alive*

Shader Variant Loading Settings
- Default chunk size (MB)*: 16
- Default chunk count*: 0
- Override

Script Compilation
- Scripting Define Symbols: RUKHANKA_WITH_NETCODE

After that setup replicated prefab as described in the `Netcode` package documentation.


Root in Prefab Asset (Open for full editing support)

✓ EllenNetcode_IG Static
Tag Untagged Layer Default

Transform

✓ Animator

Controller	EllenCrowdController_0
Avatar	EllenAvatar
Apply Root Motion	✓
Update Mode	Normal
Culling Mode	Cull Update Transforms

Clip Count: 0
Curves Pos: 0 Quat: 0 Euler: 0 Scale: 0 Muscles: 0 Generic: 0 PPtr: 0
Curves Count: 0 Constant: 0 (0.0%) Dense: 0 (0.0%) Stream: 0 (0.0%)

Rig Definition Authoring (Script)

Script	RigDefinitionAuthoring
Rig Definition	EllenRigDefinition
Root Bone	Ellen_Root (Transform)

Linked Entity Group Authoring (Script)

Ghost Authoring Component (Script)

Importance	1
Supported Ghost Modes	All
Default Ghost Mode	Interpolated
Optimization Mode	Dynamic
Has Owner	✓
Support Auto Command Target	✓
Track Interpolation Delay	☐
Ghost Group	☐
Use Pre Serialization	☐

Add Component

Both types of ghost modes are supported. For predicted ghosts, there is a prediction version of `AnimatorControllerSystem` running in `Predicted Simulation System Group`. For interpolated ghosts animation data received from a server is used as is in animation calculation. Client-only animated entities (entities that do not require synchronization) will work as usual.

There is a special demo made for **Rukhanka** Netcode features showcase.

Samples

Installation

Navigate to the `Resources/Rukhanka Animation System/Samples` directory. Import the `RukhankaSamples_HDRP.unitypackage` or `RukhankaSamples_URP.unitypackage` (depending of your rendering pipeline) package into your project. All sample scenes will be located at `Assets\RukhankaAnimationSystem\Samples`.

Basic Animation

This sample is a result of the Getting Started page of this documentation. The sample scene contains several models that play one animation each.

Bone Attachment

Entities (animated and non-animated) are handled by **Rukhanka** automatically. No extra special steps are needed. Just place your object as a child of the required bone `GameObject`. Entity hierarchy will stay intact, but **Rukhanka** will move corresponding `Entities` according to animations. This sample shows this functionality.

Animator Parameters

This sample has an animated model with a simple `Animator` created for it. Parameters that control `Animator` behavior are controlled by a simple system through UI. Controlling animator parameters from code described in Animator Parameters section of this documentation

BlendTree Showcase

Rukhanka supports all types of blend trees that Unity `Mecanim` does. This sample shows `Direct`, `1D`, `2D Simple Directional`, `2D Freeform Directional`, `2D Freeform Cartesian` blend tree types. Blend tree blend values can be controlled from in-game UI.

Avatar Mask

Avatar Masks is supported for generic (non-humanoid) animations. The use of this feature is no different than in `Unity`. Specify `Avatar Mask` and use it in Unity `Animator` to mask animation for bones. **Rukhanka** converts it into internal representation during the baking phase. This sample shows this functionality.

Multiple Blend Layers

Rukhanka has multiple animation layers support. `Additive` and `Override` layers with corresponding weights are correctly handled by **Rukhanka** runtime. In this sample, `Animator` simulates two layers represented by simple state machines.

User Curves

Custom animation curves are handled the exactly same way as they do in Unity `Mecanim`. If the animation state machine has a parameter with a name equal to the animation curve name then the value of the calculated curve at a given animation time will be copied into the parameter value. In this sample, there is an animation that has a curve whose name is the same as the animation speed parameter of the `Animator` state machine. This way animation controls its own speed. User curves are described in more detail in the User Curves section of the documentation.

Root motion

Rukhanka has limited `Root Motion` support. This sample demonstrates its use case. Root Motion features are described in detail in the corresponding section of documentation.

Animator Override Controller

Unity `Animator` has a feature called Animtor Override Controller. This feature enables to use of a different set of animations for a given preconfigured `Animator`. This feature is also supported by **Rukhanka**. This sample has an `Animator Controller` and corresponding `Animator Override Controller` which overrides several animations.

Non-Skinned Mesh Animation

Rukhanka can animate arbitrary `Entity` hierarchy with user-defined animation. This sample shows this use case. Refer to the Non-skinned Meshes page for a detailed description of this feature.

Crowd

This sample shows **Rukhanka** ability to animate a big number of different animated models. A simple prefab spawner system is used to spawn big counts of prebaked animated prefabs.

Stress Test

This sample is basically the same as the `Crowd` sample but with all skinned mesh models replaced by plain cubes. This step removes the big graphics pipeline pressure of the `Crowd` scene and keeps only raw **Rukhanka** animation system performance. This sample scene can be used for checking animation performance limits for tested systems/hardware.

Netcode Demo

Netcode demo is made for showing **Rukhanka** ability to work with the `Unity Netcode for Entities` package to achieve client-server animation synchronization in a network game. The `RUKHANKA_WITH_NETCODE` script symbol should be defined for proper demo functionality.

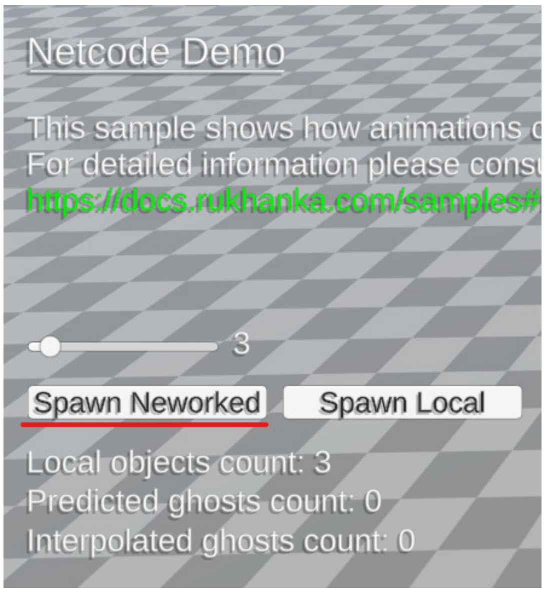
Three types of objects that can be instantiated on the scene: * Local client only. Those prefabs exist only in the client world and therefore not synchronized between client and server. To spawn such objects use the `Spawn Local` button. Client-only prefabs have a default coloring scheme to distinguish them:

`![Client Only Prefabs](images/Netcode_Spawn_Local.jpg){ width=50% }`

- Interpolated ghosts. They are colored with red-tinted materials:

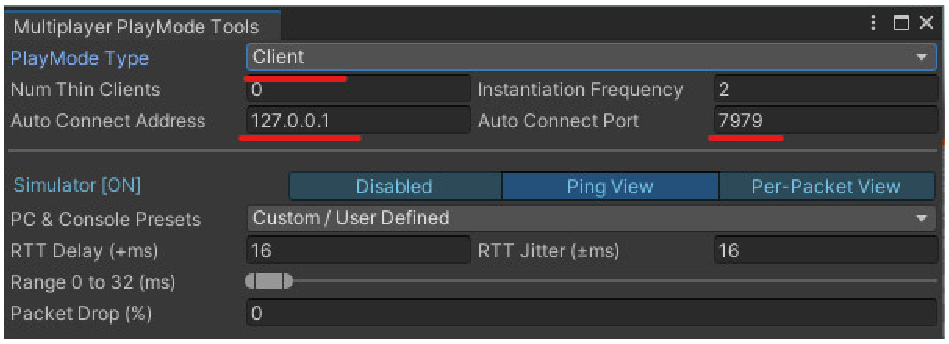
- Predicted ghosts. They are colored with green-tinted materials:

Both network synchronized prefab types can be created by pressing the `Spawn Networked` button:


Netcode Demo
This sample shows how animations c
For detailed information please consu
https://docs.rukhanka.com/samples#
3
Spawn Neworked
Spawn Local
Local objects count: 3
Predicted ghosts count: 0
Interpolated ghosts count: 0

After this demo scene has been started both client and server worlds are created and the client automatically connects to the server. To observe interpolation and prediction behavior it is advised to use `PlayMode Tools` of the `Netcode` package. By simulating various packet loss and RTT conditions, differences between ghost modes can be observed in this sample.

To even better experience you can make a build with this scene, run it and then connect with another client instance directly from the editor by modifying the play mode type in `PlayMode Tools`. Use IP address 127.0.0.1 (localhost) and port 7979:


Multiplayer PlayMode Tools

PlayMode Type: Client
Num Thin Clients: 0
Instantiation Frequency: 2
Auto Connect Address: 127.0.0.1
Auto Connect Port: 7979

Simulator [ON] — Disabled | Ping View | Per-Packet View
PC & Console Presets: Custom / User Defined
RTT Delay (+ms): 16
RTT Jitter (±ms): 16
Range 0 to 32 (ms)
Packet Drop (%): 0

Using this test environment you can spawn networked prefabs from both of the clients and watch how they are replicated by the server.

Animator State Query

This sample shows the usage of the runtime animator query aspect. Every frame animator queried for its runtime state and transition and received information shown in scene UI.

Tips

Perfomance Optimization Tips

There are several performance optimization tips for **Rukhanka**:

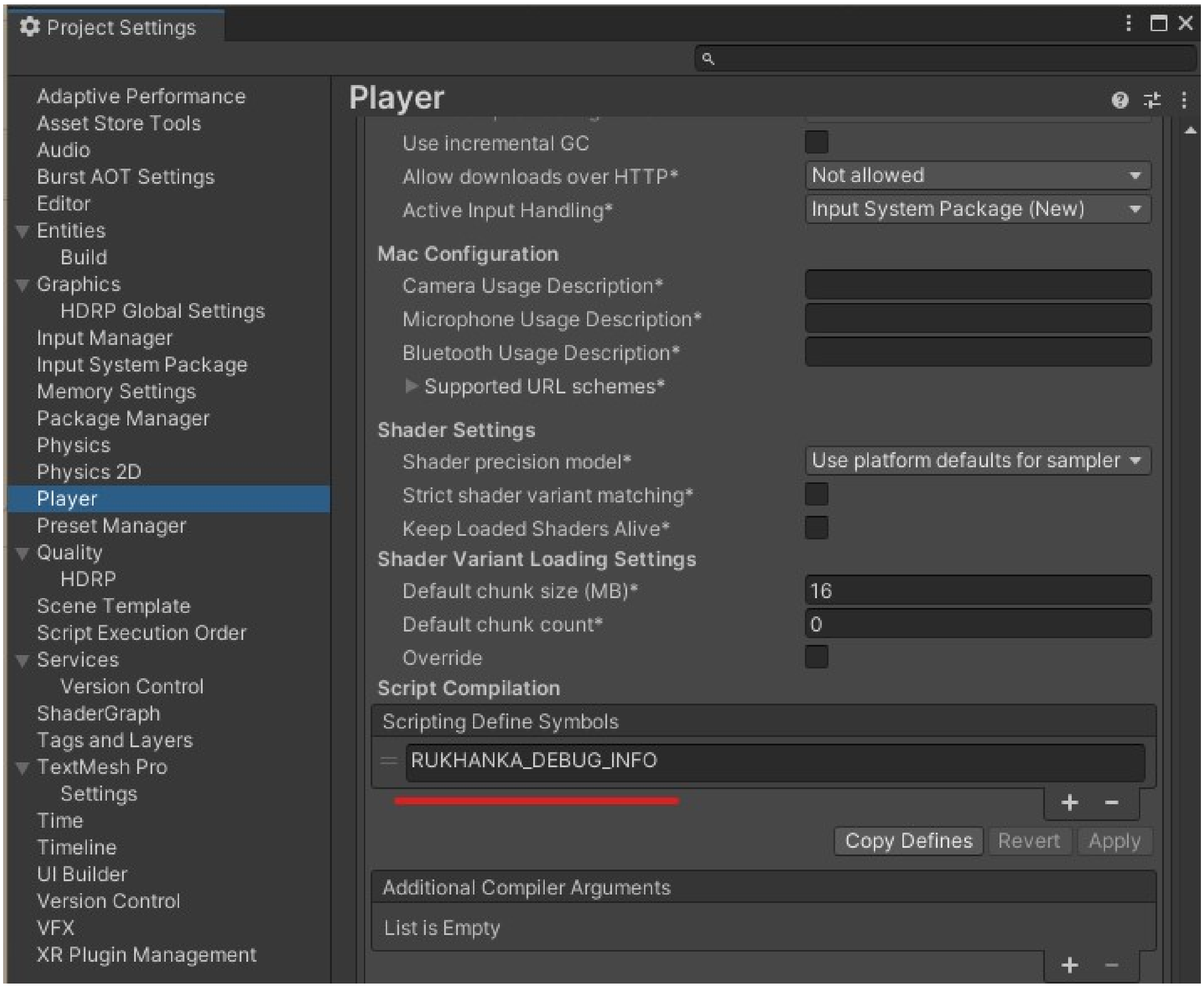
- Lower total bone count. **Rukhanka** splits animation workload per bone and not per entity. This allows full utilize all available processor power for low bone count meshes as well as high bone count. So overall performance will depend on total bone count linearly.
- Additive animations are as twice slow as normal ones. Heavy use of additive animations will be slower than ordinary.
- Do not forget to disable `RUHANKA_DEBUG_INFO` during performance tests.

Debug and Validation

Extended Validation Layer

Despite that the animation system heavily depends on name relations between components (bone names, animation parameter names, state machine state names, etc), `string` values are used only in bake time. Bake systems convert all `string` values into `Hash128` representations and work with them in runtime. No string data is available during state machines and animation processing. This approach is very performant but debugging and validation in case of issues become very complicated.

To make the easier process of watching for state and parameter changing, debugging, and detailed logging of baking processes, **Rukhanka** introduces a special `extended validation` mode. This mode can be enabled by adding the `RUKHANKA_DEBUG_INFO` script definition symbol into project preferences:



Player

Use incremental GC	☐
Allow downloads over HTTP*	Not allowed
Active Input Handling*	Input System Package (New)
Mac Configuration	
Camera Usage Description*	
Microphone Usage Description*	
Bluetooth Usage Description*	
Supported URL schemes*	
Shader Settings	
Shader precision model*	Use platform defaults for sampler
Strict shader variant matching*	☐
Keep Loaded Shaders Alive*	☐
Shader Variant Loading Settings	
Default chunk size (MB)*	16
Default chunk count*	0
Override	☐
Script Compilation	

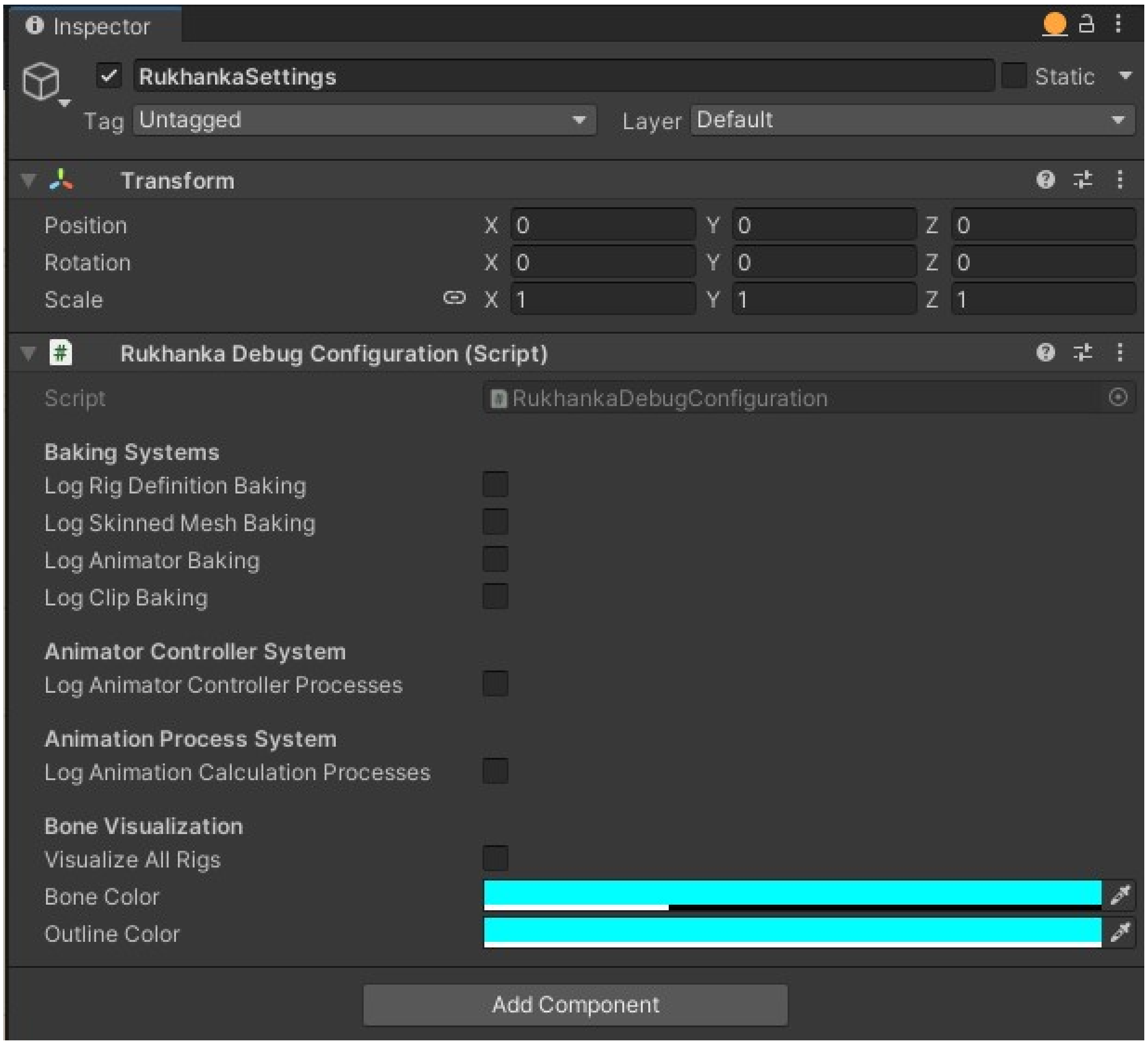
Scripting Define Symbols
RUKHANKA_DEBUG_INFO

Additional Compiler Arguments
List is Empty

Adding this symbol, **Rukhanka** will add to all internal structures its corresponding string fields (FixedString or BlobString for `Burst` compatibility where appropriate). Watching these members in the debugger and logging makes it much easier to investigate and fix problems in animations

Logging capabilities

By defining `RUKHANKA_DEBUG_INFO` extended logging and visualization capabilities have also become available. To configure them add the `Rukhanka Debug Configuration` authoring component to any `GameObject` inside `Entities Subscene`.


Inspector

RukhankaSettings

Static

Tag Untagged

Layer Default

Transform

Position X 0 Y 0 Z 0

Rotation X 0 Y 0 Z 0

Scale X 1 Y 1 Z 1

Rukhanka Debug Configuration (Script)

Script RukhankaDebugConfiguration

Baking Systems

Log Rig Definition Baking ☐

Log Skinned Mesh Baking ☐

Log Animator Baking ☐

Log Clip Baking ☐

Animator Controller System

Log Animator Controller Processes ☐

Animation Process System

Log Animation Calculation Processes ☐

Bone Visualization

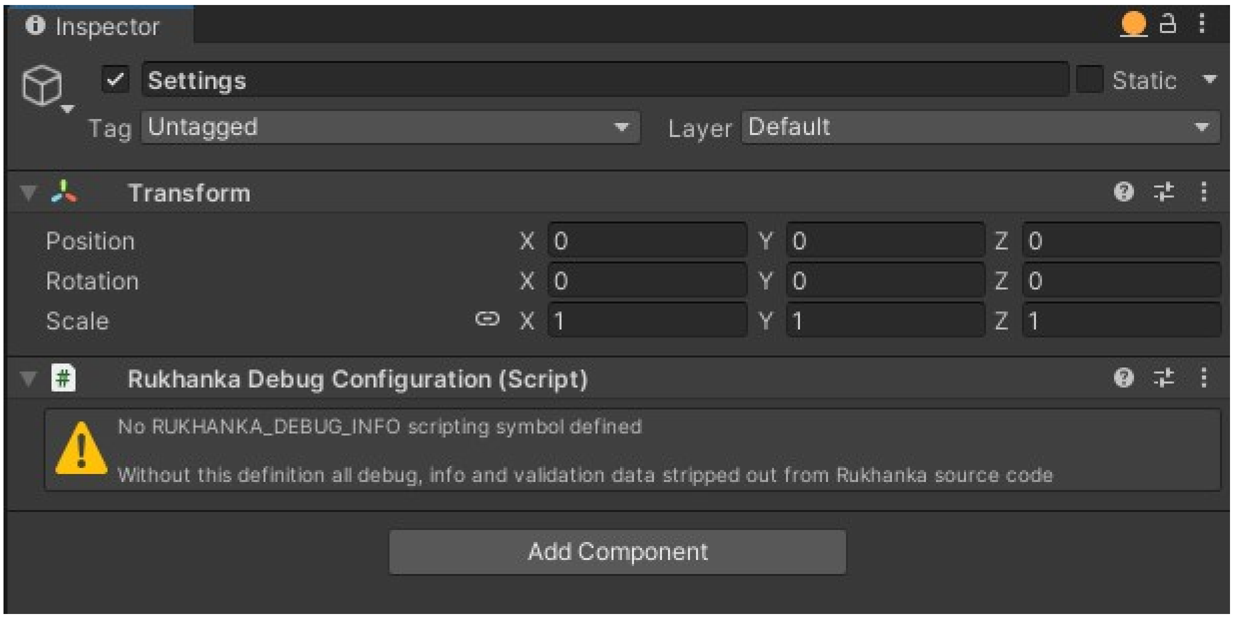
Visualize All Rigs ☐

Bone Color

Outline Color

Add Component

If `RUKHANKA_DEBUG_INFO` is not defined this configuration script will show a warning message and no configuration options will be available:


Inspector

Settings

Static

Tag Untagged

Layer Default

Transform

Position X 0 Y 0 Z 0

Rotation X 0 Y 0 Z 0

Scale X 1 Y 1 Z 1

Rukhanka Debug Configuration (Script)

No RUKHANKA_DEBUG_INFO scripting symbol defined

Without this definition all debug, info and validation data stripped out from Rukhanka source code

Add Component

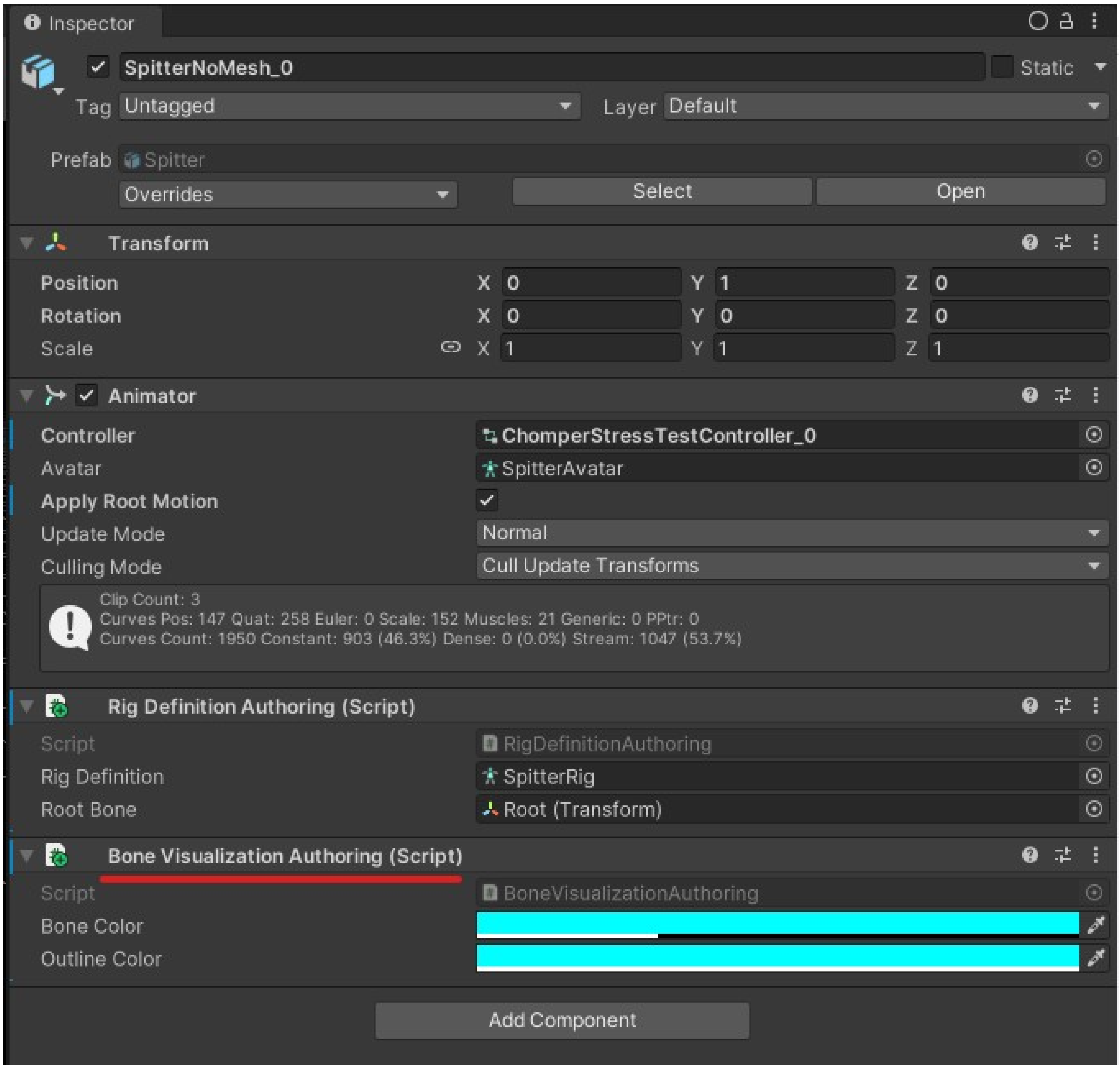
- *Baking Systems* logging will log a total of `Authoring Components` baked as well as additional warnings and messages during the baking process.

- *Animator Controller System* logging will enable the log of animator controller internal state changes and additional details.
- _Animation Process System__ logging will enable the log of animation core internal details during runtime.
- *Bone Visualization* enables internal bone renderer for all **Rukhanka** `Rigs`.

Bone Visualization

There are two options to enable *Bone Visualization* capability for **Rukhanka** `Rig`:

1. Enable bone visualization for all meshes in the scene. This is done by the checkbox described in the previous section on this page.
2. Add the `Bone Visualization Authoring` component to the required animated object. Note that this way bone visualization will work even without `RUHANKA_DEBUG_INFO` defined.


Inspector

SpitterNoMesh_0 — Static
Tag Untagged — Layer Default
Prefab Spitter
Overrides — Select — Open

Transform
Position X 0 Y 1 Z 0
Rotation X 0 Y 0 Z 0
Scale X 1 Y 1 Z 1

Animator
Controller ChomperStressTestController_0
Avatar SpitterAvatar
Apply Root Motion ✓
Update Mode Normal
Culling Mode Cull Update Transforms

```
Clip Count: 3
Curves Pos: 147 Quat: 258 Euler: 0 Scale: 152 Muscles: 21 Generic: 0 PPtr: 0
Curves Count: 1950 Constant: 903 (46.3%) Dense: 0 (0.0%) Stream: 1047 (53.7%)
```

Rig Definition Authoring (Script)
Script RigDefinitionAuthoring
Rig Definition SpitterRig
Root Bone Root (Transform)

Bone Visualization Authoring (Script)
Script BoneVisualizationAuthoring
Bone Color
Outline Color

Add Component

Changelog

[1.2.1]

Fixed

- Fixed compilation errors during standalone builds creation.

[1.2.0]

Added

- Compute deformation node for `Amplify Shader Editor`. Now it is possible to make `Entities.Graphics` deformation-compatible shaders with this tool.
- Trigger set API for `AnimatorParametersAspect`.
- The animator parameter access performance tests.
- Own entity command buffer system for optimizing ECB usage after `AnimationControllerSystem`.
- `AnimatorStateQuery` aspect for access to runtime animator data.

Changed

- Animator parameter internal hash code representation was moved from `Hash128` to uint. This leads to a smaller `AnimatorControllerParameterComponent` size and better chunk utilization.

Fixed

- The state machine states without an assigned motion field had incorrect weight calculations.
- Exit and enter transition events that happened in the same frame lead to one incorrectly processed frame. This was clearly observable with transitions from/to "no-motion" states.
- Trigger parameters were reset even if the transition cumulative condition (all conditions must be true) is not met.
- Entering through the sub-state machine's `Enter` state was handled incorrectly.
- Exiting from nested sub-state machines using the `Exit` state was handled incorrectly.
- Multiple transitions from the `Enter` state machine state were handled incorrectly.

[1.1.0]

Added

- `Unity Netcode for Entities` package support. Animations and controllers can be synchronized using interpolated and predicted modes.
- New `Netcode Demo` sample with **Rukhanka** and `Netcode for Entities` collaboration showcase.
- Animator parameter aspect to simplify animator controller parameter data manipulation.

Changed

- Minimum `Entities` and `Entities.Graphics` packages version is 1.0.10.

Fixed

- State machine transitions with exit time 0 were handled incorrectly.
- Transitions with exit time 1 are looped contrary to Unity documentation. **Rukhanka** behavior changed to match `Mecanim` in this aspect.
- Various deprecated API usage warnings.

[1.0.3]

Added

- Adding authoring Unity.Animator and all used Unity.Animation in the baker dependency list.
- Extended animator controller logging with RUKHANKA_DEBUG_INFO which displays all states parameters and transitions of baked state machines.

Fixed

- Incorrect handling of very small transition exit time during state loops.
- Preventing NANs (division by zero) when transition duration is zero.
- Memory allocation error in PerfectHash tests.
- Controller parameters order in authoring animator does not coincide with generated `AnimatorControllerParameter` buffer.
- Empty animations to process buffer were handled incorrectly.
- Exit states of state machines are now handled properly.
- Animator state `Cycle Offset` treated as animation normalized time offset as in `Unity.Animator`.

[1.0.2]

Fixed

- Entities 1.0.0-pre.65 and Entities.Graphics 1.0.0-pre.65 support.

[1.0.1]

Added

- IEnableableComponent interface for AnimatorControllerLayerComponent and RigDefinitionComponent.
- Decsription of main **Rukhanka** entity components.

Changed

- `Crowd` and `Stress Test` samples now have control for skeleton visualization enabling (with RUKHANKA_DEBUG_INFO defined).
- `Crowd` and `Stress Test` samples now show total number of animated bones in scene.

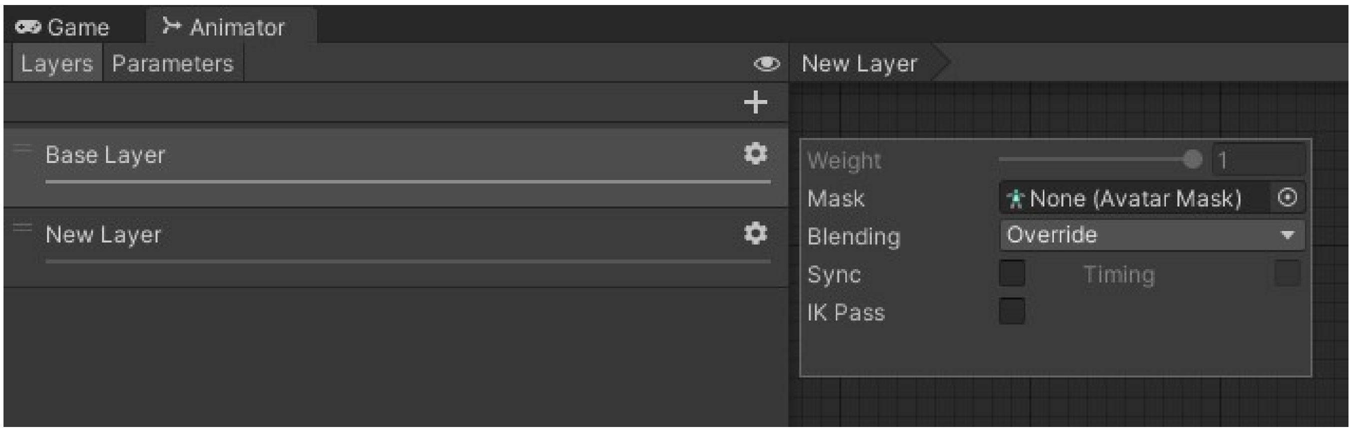
Fixed

- Incorrect handling handling of uniform scale in animations.

[1.0.0] - Initial release

Feature Support Tables

Animator Controller Layer

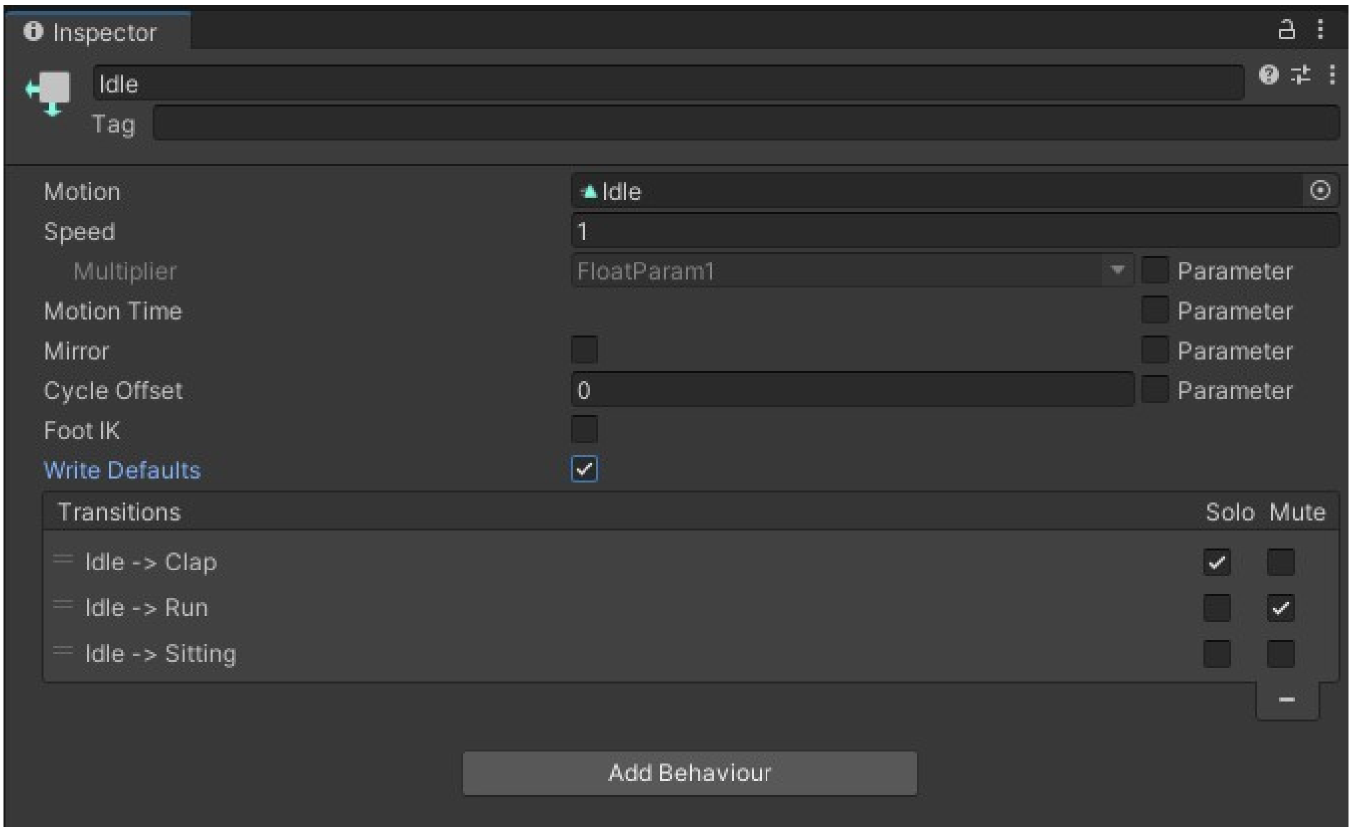


New Layer

Weight 1
Mask None (Avatar Mask)
Blending Override
Sync
Timing
IK Pass

Feature Name	Support Status	Additional Notes
Multiple Layers	+	
Sub-State Machines	+	
Weight	+	
Mask	+	
Override Blending	+	
Additive Blending	+	
Sync	-	
IK Pass	-	

Animator State



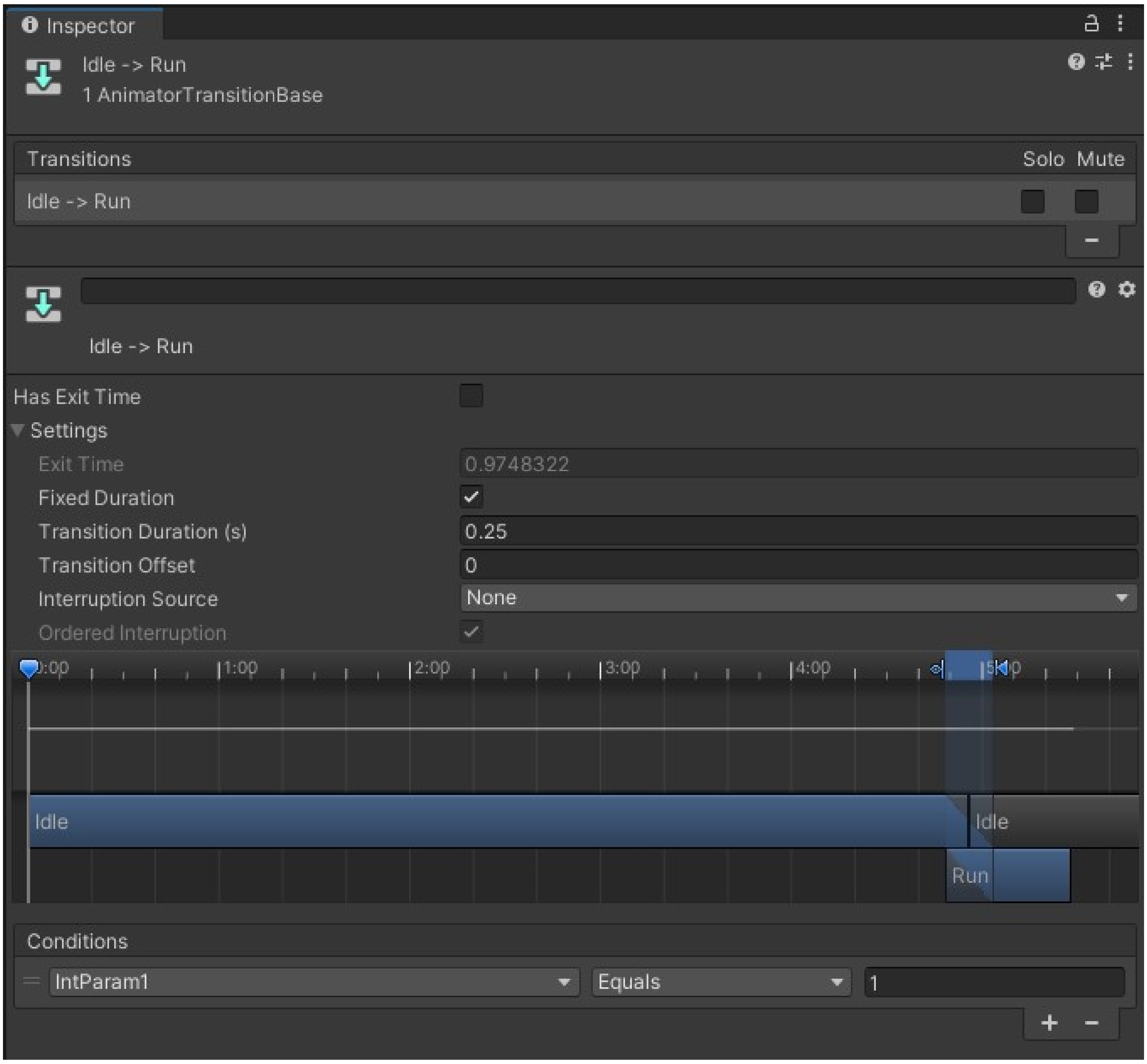
Idle
Tag

Motion Idle
Speed 1
Multiplier FloatParam1 Parameter
Motion Time Parameter
Mirror Parameter
Cycle Offset 0 Parameter
Foot IK
Write Defaults ✓

Transitions	Solo	Mute
Idle -> Clap	✓	
Idle -> Run		✓
Idle -> Sitting		

Feature Name	Support Status	Additional Notes
Motion	+	
Speed	+	
Speed Multiplier	+	
Motion Time	+	
Mirror	-	
Cycle Offset	+	
Foot IK	-	
Write Defaults	-	

Animator Transition


Inspector

Idle -> Run
1 AnimatorTransitionBase

Transitions | Solo | Mute
Idle -> Run

Idle -> Run

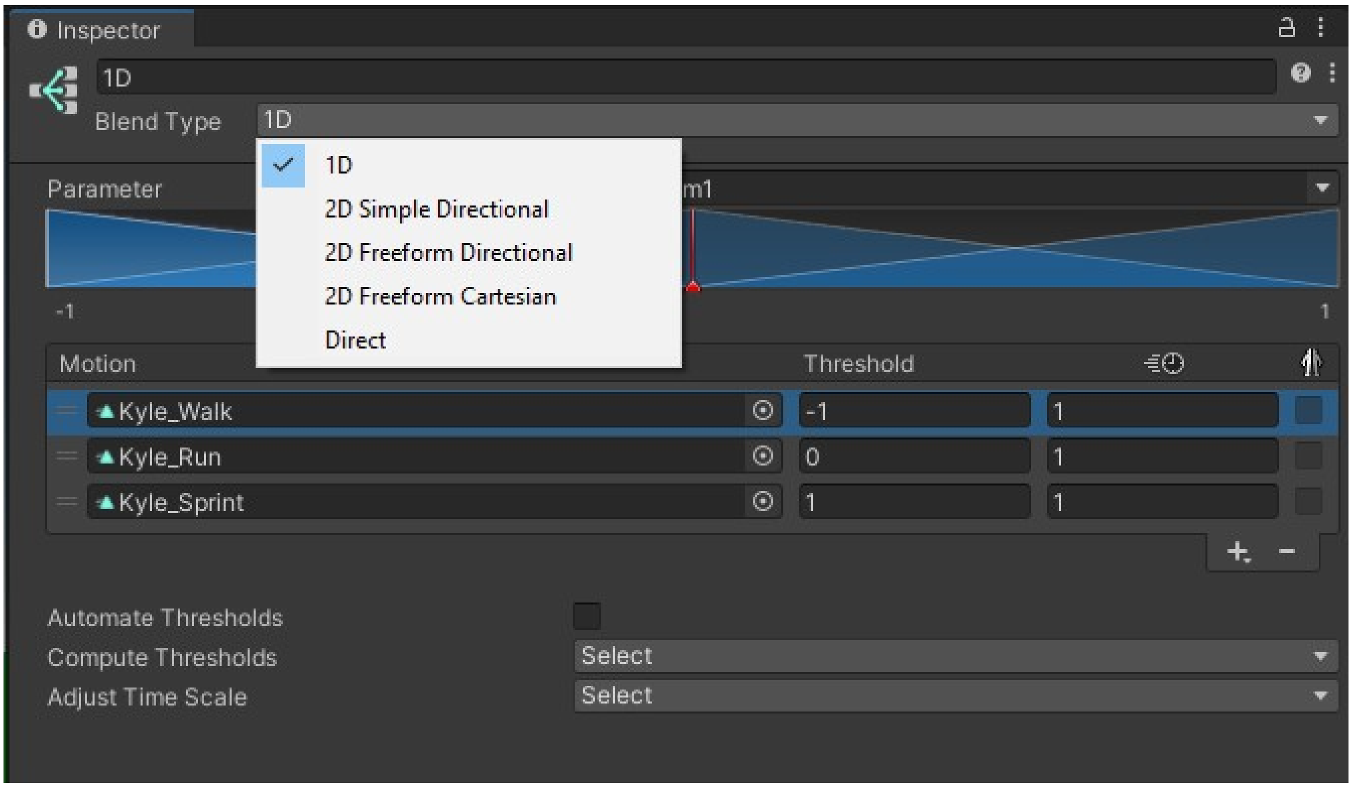
Has Exit Time: ☐
Settings
Exit Time: 0.9748322
Fixed Duration: ✓
Transition Duration (s): 0.25
Transition Offset: 0
Interruption Source: None
Ordered Interruption: ✓

Conditions
IntParam1 | Equals | 1

Feature Name	Support Status	Additional Notes
Solo	+	
Mute	+	
Has Exit Time	+	
Exit Time	+	
Fixed Duration	+	

Feature Name	Support Status	Additional Notes
Transition Duration	+	
Transition Offset	+	
Interruption Source	-	
Ordered Interruption	-	
Can Transition To Self	+	Available only in `Any State`
Int Conditions	+	
Float Conditions	+	
Bool Conditions	+	
Trigger Conditions	+	

Blend Tree Features



1D

Blend Type: 1D

Parameter: m1

Motion	Threshold		
Kyle_Walk	-1	1	
Kyle_Run	0	1	
Kyle_Sprint	1	1	

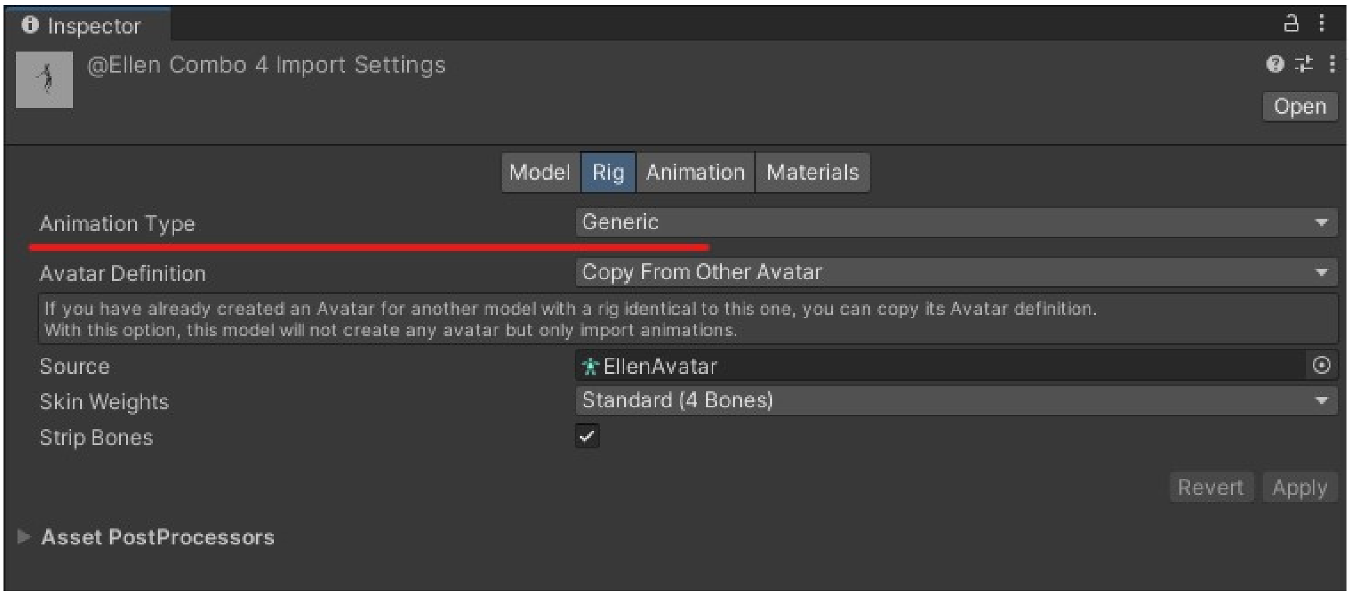
Automate Thresholds

Compute Thresholds: Select

Adjust Time Scale: Select

Feature Name	Support Status	Additional Notes
1D	+	
2D Simple Directional	+	
2D Freeform Directional	+	
2D Freeform Cartesian	+	
Direct	+	
Automate Thresholds	o	Not handled by **Rukhanka**
Compute Thresholds	o	Not handled by **Rukhanka**
Adjust Time Scale	o	Not handled by **Rukhanka**

Animation Rig Properties


Inspector
@Ellen Combo 4 Import Settings
Open
Model | Rig | Animation | Materials

Animation Type: Generic
Avatar Definition: Copy From Other Avatar

If you have already created an Avatar for another model with a rig identical to this one, you can copy its Avatar definition.
With this option, this model will not create any avatar but only import animations.

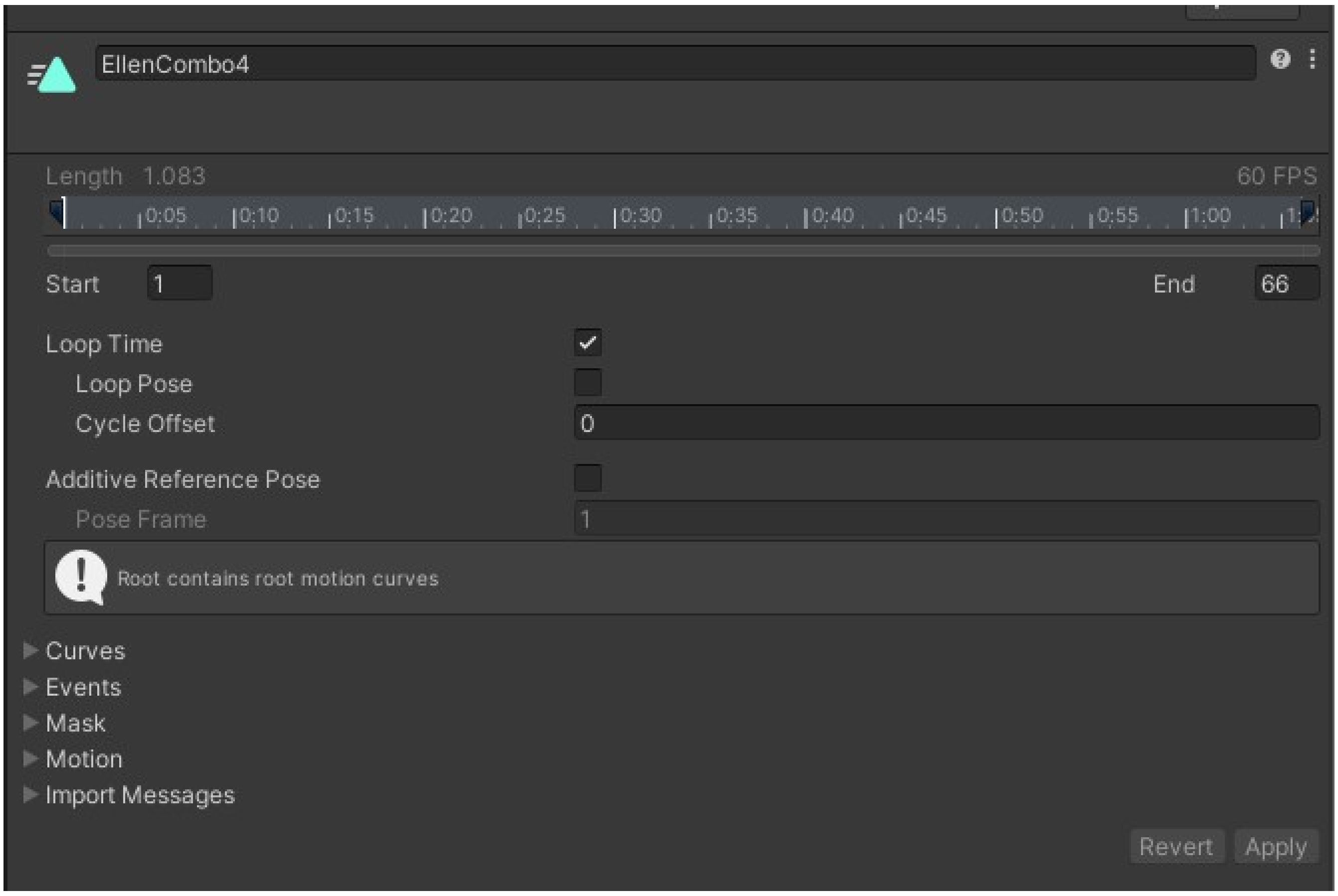
Source: EllenAvatar
Skin Weights: Standard (4 Bones)
Strip Bones: ✓

Revert Apply

Asset PostProcessors

Feature Name	Support Status	Additional Notes
Animation Type *Generic*	+	
Animation Type *Legacy*	-	
Animation Type *Humanoid*	-	

Animation Properties


EllenCombo4

Length 1.083 60 FPS

Start: 1 End: 66

Loop Time: ✓
Loop Pose:
Cycle Offset: 0

Additive Reference Pose:
Pose Frame: 1

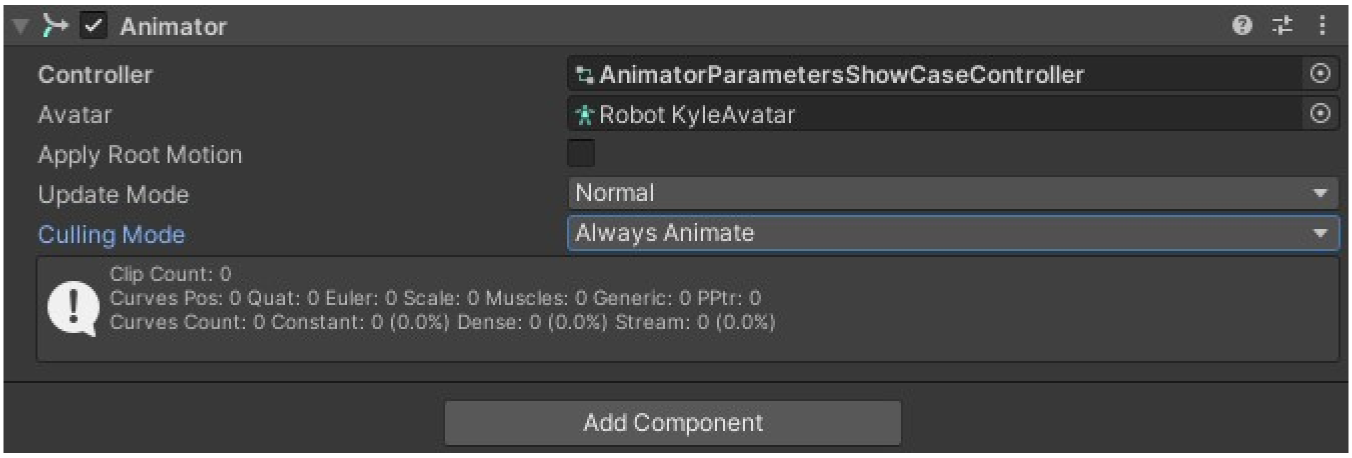
Root contains root motion curves

Curves
Events
Mask
Motion
Import Messages

Revert Apply

Feature Name	Support Status	Additional Notes
Loop Time	+	
Loop Pose	+	
Cycle Offset	+	
Additive Reference Pose	+	
Pose Frame	+	
Curves	+	Documentation
Events	-	
Mask	-	
Motion	+	Documentation
Generic Root Curves	-	`Root T` and `Root Q`

Animator Features



Controller: AnimatorParametersShowCaseController
Avatar: Robot KyleAvatar
Apply Root Motion: ☐
Update Mode: Normal
Culling Mode: Always Animate

```
Clip Count: 0
Curves Pos: 0 Quat: 0 Euler: 0 Scale: 0 Muscles: 0 Generic: 0 PPtr: 0
Curves Count: 0 Constant: 0 (0.0%) Dense: 0 (0.0%) Stream: 0 (0.0%)
```

Feature Name	Support Status	Additional Notes
Controller	+	
Avatar	-	Need to be configured separately
Apply Root Motion	o	Partial. Read the docs
Update Mode	-	
Culling Mode	-	