A

User Manual

Tames Version ~~0.93~~1 beta

Manual Revision ~~3~~ 4 for Beginners

Contents

1 Introduction

Tames is Unity toolkit that is intended to facilitate architects' creation of dynamic, immersive, and interactive visualisation of their works and research. This is a provisional manual for readers to familiarise them with the concept. Both the toolkit and this manual are still in process of developing and there may be inconsistencies and flaws in either or both.

2 Preparation

For using Tames, you need to have a version of Unity Editor (2021.3.20 and above) installed on your PC. Once you made sure you have the proper version of Unity, you would only need to copy Tames folder in your desired location, ideally on an SSD storage for faster loading and updating. Please note that you need a separate folder for each project, so we recommend keeping the original Tames folder intact to be able to copy it multiple times. Please also mind that despite the low size of the toolkit, Unity will add around 1+GB of files to each project.

For the first time opening a project, click Open in Unity Hub and select your folder (the project will appear in the list below it for later use). Unity will take minutes to create the requirements for the project.

You can import a number of 3D formats into Unity. Usually models created with BIM tools are converted to FBX format, and then imported into Unity (or first imported and optimized into a 3D modelling application). After importing a file, it is important to check the Read/Write Enabled option so that Tames can read the vertex data of the model. This option is available at the Model tab of the prefab's inspector tab:

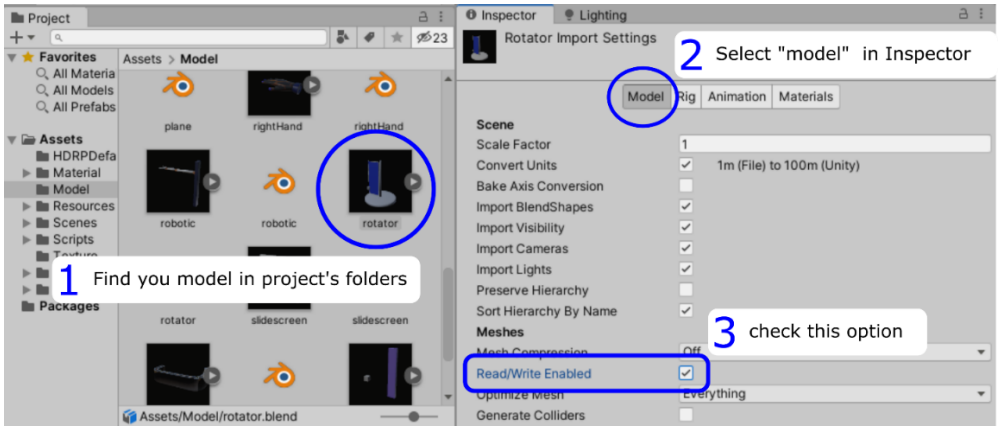


Figure 1.

3 How does Tames work?

Let's consider that everything has a predefined path of change and movement. For example, a sliding door only slides on a line between two points. Or, a light can only change its intensity from one value to another. Therefore, the only parameter that we need to know for an element's update is its progress on that predefined path, which is simply a percentage or a number between 0 and 1. This value is called the *progress*.

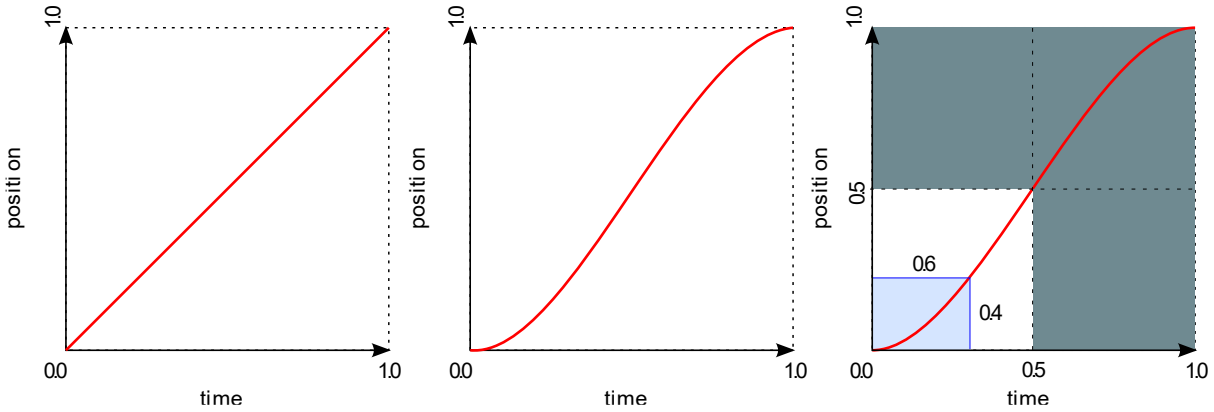
Duration, direction and continuity mode

Of course, Tames needs to know when and how the progress value changes. For example, why should the sliding door open and how fast it should? Each element has several properties that help us clarify these questions for Tames:

- *Duration* of a progress tells us how long (in seconds) it takes for the element to change by one length of its changing path. Its reciprocal value, *speed*, tells us what portion of the progress is passed in every second. This duration is linear and may not feel smooth for 3D objects. For a smooth change, a lerp is used (see below)
- *Direction* of the progress defines if the progress value decreases, stalls or increases as time passes. The direction is applied on the speed value as a mulitiplicative factor of -1, 0 or +1.
- *Continuity mode* defines what happen when the element reaches the end of the path. The sliding door, for example, should stop when it reaches the end of its rail. However, a revolving door may continue to spin after each 360-degree turn. Tames allows three continuity modes: *stop*, *cycle* and *reverse*.

Lerp

Lerping is the change of speed of something, especially when it closes its end of movement. It is very useful to simulate acceleration and deceleration of objects. It works with manipulating the linear association of time and position. For example, imagine an object moves 1m from A to B in 1s. So, its speed is 1m/s. In the left graph below, the speed is constant and so the position changes linearly as time passes. This means, at time 0, the object instantly changes its speed from 0 to 1m/s. In reality, this is impossible as it means an acceleration of (near) infinity. Instead, the object gradually reaches that speed, though in a short time. The graph in the middle shows a more realistic and *lerp*ed correspondence between time and position. In Tames, this is set by two numbers showing how long and how far it takes to reach that linear speed (right graph). These numbers (separated by comma) are between 0 and 1 but are relative to *half* of time span.



These ~~three~~ above properties are essential in every automatic change. However, they don't clarify why an element should change to begin with. This is defined by update bases, interaction logics and triggers.

In the examples above, the basis of update was time. When time passes, the element would change based on its speed, direction and continuity mode. However, it is possible to associate update an element based on other elements. For example, imagine an old clock with a pendulum and three hands. The movement of the clock hands depends on the pendulum though they move

at different speeds. To establish this relation, we need to tell Tames to update the hands based on the pendulum. So, if we were to right the relationships, it would be like below:

Object	Duration (s)	Continuity	Update basis
Pendulum	1	Reverse	Time
Seconds hand	60	Cycle	Pendulum
Minutes hand	3600	Cycle	Pendulum
Hours hand	43200 (12 hours)	cycle	Pendulum

However, elements are not always continuously changing. Consider that the above clock had a cuckoo alarm that was set on 7AM and 7PM. That cuckoo would come out and in seven times within seven seconds. This means it has a reverse continuity mode, with each turn taking half a second. It should start at hour 7:00:00 and stop at 7:00:07. So, we will have something like this:

Object	Duration (s)	Continuity	Update basis
Cuckoo	0.5	Reverse	Hours

Trigger

But how do we limit the activation to between 7:00:00 and 7:00:07? The answer is by a *trigger*:

0.5833333+0.5834953

The above line is simpler than it looks. Let's begin with the numbers. The first number is 7/12 (hour 7 from 12 hours). The second number represents 7:00:07 out of 12 hours. It tells tames to pay attention to when the progress value of the hours hand, i.e., the update basis of our cuckoo, reaches these numbers. The second important part of the line is the signs, or lack thereof, between and around the numbers. This combination is in fact:

EMPTY*0.5833333+0.5834953****EMPTY***

If you remember earlier, we talked about the three possible directions of changing progress represented by three numbers: -1, 0 and +1. In the trigger line, we defined the directions: 0 or still before 7:00, +1 or positive change after 7:00, and still again after 7:00:07.

An update basis is not the only factor in triggering a change. Remember the sliding door? Its movement is triggered by the presence of people near it. For this we need to define spatial triggers.

Interaction areas or spatial triggers

With interaction areas, the change direction is defined by presence or absence of a person within designated 3D areas, which imitate a sensor in the real world. For example, a cubic area around an automatic door can convert the presence of a person inside it to a positive direction (from closed to open) and the absence to a negative direction (from open to closed). Unlike the previous progress-based triggers, spatial triggers are defined in the 3D models not in text.

An interaction area is a simple 3D geometry (box, sphere, cylinder or plane) that when a person enters it will change the direction of the progress in the attached element. Like the trigger, the

direction change is based on a ternary factor (-1, 0, or +1) multiplied on the progress's speed. There are seven ways or *modes* to manage direction with interaction areas. For four modes, a person (**head**) being inside or outside is associated with the direction factor, and for the next three, the moment of a **hand** entering matters:

Mode	Part	Tag	Inside	Outside	On entering
Inside only	Head	In	+1	0	-
Outside only	Head	Out	0	+1	-
Negative inside	Head	Neg	-1	+1	-
Positive inside	Head	Pos	+1	-1	-
On/Off Switch	Hand	1	-	-	Switch between 0 and +1
Two-state switch	Hand	2	-	-	Switch between -1 and +1
Three-state switch	Hand	3	-	-	Switch between -1, 0 and +1

There is also a manual interaction, called **grip** (with tag **g**) that overrides all other interaction and progress properties. It is activated when the hand makes a grabbing gesture inside the area. Then, the element is attached to the hand, with its progress changes as the hand moves while holding the grip.

The easiest way to use interaction areas is to create them in your 3D modelling software as simple solid objects and make them children to the object that represents your dynamic element. However, it is important to follow a few naming rules so that Tames can understand the object is an interaction area (alternatively, you can use Marker Components in Unity). The name of an interaction area starts with an underscore (_) followed by its shape (only the first three letter suffice), then another underscore, followed by the tag of its mode. For example, *_box_g* defines a grip area with the shape of a box or *_cyl_in* defines a cylindrical area that activates an element only if you are inside it.

4 Types of elements

Four types of dynamic elements are possible in Tames:

- 3D elements that are object with a moving child object
- Materials with possible changeable properties, including: albedo and emissive colour, U and V offsets of the main and emissive textures, and intensity of emission.
- Lights with possible changeable properties including: colour, intensity and angle (for spot lights).
- Numerical or custom elements that are not visual and only consist of a progress value.

For defining custom elements and converting scene materials, lights into interactive ones, you need to use Unity components. For 3D elements, you can either define them in 3D models or by components.

4.1 Changers

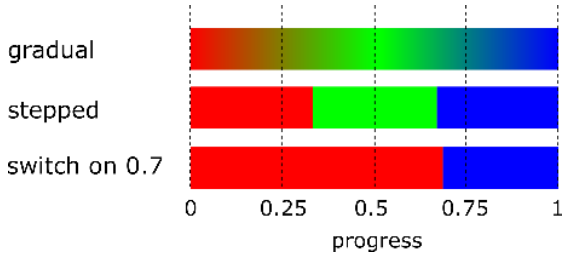
Changes in material and lights are based on a structure called Changer. This structure modifies a property by a mode of change and a custom number of steps (minimum of two) which represent the progress value. For example, if a light is turned on, it can be done in two ways:

1. The value of its intensity property should go from step *0* lux to step *100* lux (for example).

2. Or the value of its colour property should go from step *black* to step *white*.

The mode of change defines when and how smoothly the transition between the steps happen. There are three modes:

1. *Stepped* defines an abrupt change. So, the value of the property is always equal to one of the steps.
2. *Gradual* defines a gradual change. The value of the property is calculated based on the progress value's position between the steps.
3. *Switch* creates a threshold before which the property value is the first step and after it is the last.



Three modes of change for a colour property (the steps are red, green and blue).

5 Basic 3D modelling for Tames

Tames requires certain characteristics in a 3D model for it to be identified as a dynamic or interactive object. These characteristics can be included in either or both the 3D modelling software and Unity Editor. In summary, to define the movements of a 3D object, we need the movement's path and the base direction of moving on the path. In the 3D model, these requirements can be met by **child** objects whose names starts with *_mov*, *_path*, *_start* and *_end*.

This tell Tames that the object *_mov* moves along with *_path* in a direction defined by *_start* and *_end*. If such marker objects are included, Tames identifies their **parent** object as a dynamic element. The hierarchy of these objects is **important** for Tames to correctly identify them (Figure 5.1).

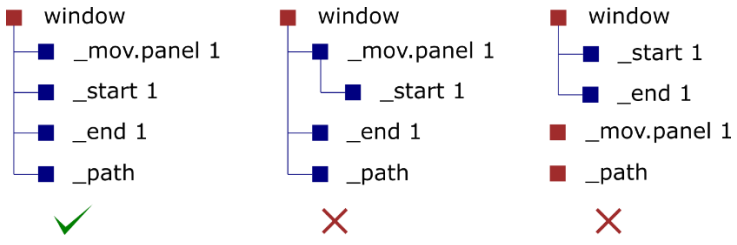


Figure 5.1. All of the marking objects should be child of the same parent (left).

Important Rules

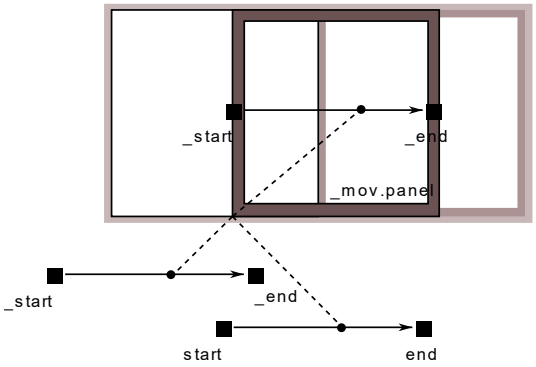
- If you include a path object, the imported model that includes that object should have a readable mesh (see **Error! Reference source not found.**~~**Error! Reference source not found.Error! Reference source not found.**~~8.2.1**Error! Reference source not**

found.~~Error! Reference source not found.Error! Reference source not found.~~8.2.1~~)~~).

- Only the initial position of the marker objects, relative to the parent object, is recorded. Later changes to them will not affect the pathing of the latter.
- Each element can only have one marker of each kind (one path, one moving object, etc.). Additional markers are ignored.
- Only the start of the object's name should match with the marker names. So, you can have objects named *_pathsdfsdf* or *_path.123* and they are still valid.
- The path should be a stripe with only one segment on its width. Otherwise, Tames will not recognize it correctly.

5.1 Sliding objects

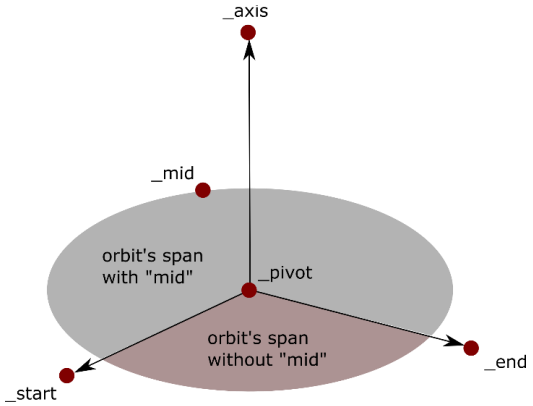
Sliding objects are simplified pathed objects that can only slide on a straight line. Hence, they don't need a *_path* marker but just *_start* and *_end* ones. The moving part slides **parallel to** the vector between start and end **not on** it (Figure 5.2).



Regardless of where the start and end markers are, the moving panel behaves the same as long as their vectors have the same direction and magnitude.

5.2 Orbiting objects

Orbiting objects rotate around an axis. The axis is a vector between *_pivot* and *_axis* markers. A *_start* marker is necessary to indicate the starting angle of the orbiting. An optional *_end* marker determines the span of rotation (its absence means the rotation is 360 degrees). To distinguish between rotation angles under and above 180 degrees, a *_mid* marker is necessary for the latter to identify the larger angle between the start and end points (Figure 5.3).



Using *_mid* marker to define a wide orbiting span.

5.3 Revolving object

Revolving objects rotate around themselves (in contrast to orbiting objects that rotate around an external axis). They are defined in conjunction with pathed or orbiting objects with the marker *_up*. This marker defines the revolving axis which limits their revolution when they are orbiting or moving on the path. In case of pathed objects, this axis is between *_start* and *_up* and for orbiting objects it is between *_pivot* and *_up*. If *_up* is on the same point as the other point of the axis, the object is deemed fixed and it will not rotate. If the *_up* marker is not present, the object will revolve freely (following either the orbit or path's geometry).

The list of all element-defining markers is in the following table:

Marker combinations

Mandatory	Additional markers	Usage
	_end	Sliding element
	_pivot, _axis	Orbiting element (full circle)
	_end, _pivot, _axis	Orbiting element (limited angle <180˚)
_mov, _start	_mid, _pivot, _axis	Orbiting element (limited angle defined by _mid)
	_mid, _end, _pivot, _axis	Orbiting element (limited angle defined by _mid and _end)
	_end, _path	Pathed element

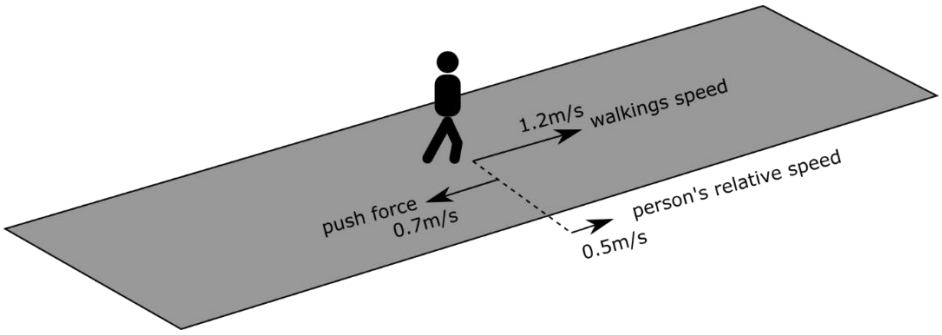
In all non-sliding combinations, you can include an *_up* marker.

5.4 People's movement

You can limit the movement of people with walkable surfaces. A walkable surface is part of a 3D object that limits the movement of camera on it. When they are imported, their upward-facing surfaces are detected and stored as the navigable area of the space. To define an object as walkable you need to add a Marker Walk component to it (See 5.3).

To walk smoothly in the space, the walkable surfaces must be attached on the plan and be close to each other on vertical sections (less than 30cm level difference) on the section, otherwise, the movement between them will be invalid and impossible. Of course, if the walkable objects move their attachment and proximity may change and alter the walkability on their edges.

You can assign a pushing force to a surface. A pushing force is a velocity vector that affects a person's default moving vector. Pushing forces are useful to simulate walkways and escalators.



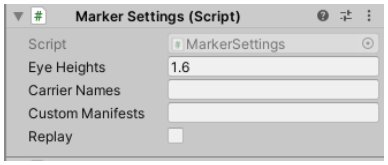
Defining pushing forces works similar to defining moving objects, with only differences in the marker names (we add an "f" in the beginning of the marker name's text). Instead of *_path*,

_start, *_end*, *_pivot* and *_axis*, we would have *_fpath*, *_fstart*, *_wend*, *_fpivot* and *_faxis*. We can have sliding, rotating and pathed pushing forces, however, the usage of the markers is different. You **cannot** define the markers with components in this version.

For sliding and pathed push, *_fstart* and *_fend* still indicate the direction of the push, but their distance represents the velocity (in m/s) or the force of the push. In rotating push forces, there is no start and end, but only *_fpivot* and *_faxis* that represent both the rotation axis and its angular velocity by their distance (each unit would be 360 degrees per second). The direction of rotation is determined by the direction of the axis (clockwise if you look towards the axis' direction).

6 Unity Compenents

6.1 General settings

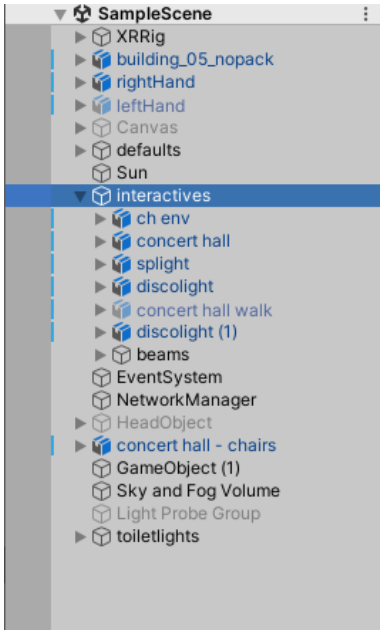


A Setting component is added by default to the root object *interactives*.

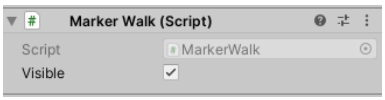
- **Eye heights**: separated by commas, you can put various eye heights (i.e. the camera's Y difference to the nearest walking floor). You can switch between them by pressing Z during the Play session.
- ~~**Carrier names**: you can attach your camera to different objects, whose names you write here (separated by comma). You can toggle between them with X key.~~
- **Custom manifest**: advanced feature not covered in this manual.
- **Replay**: in a **future** version checking this will make Tames to replay and re-enact saved sessions.

6.2 Interactive elements

When importing interactive elements, they should be children or descendants of a game object named *interactives*. Otherwise, they are ignored by Tames.

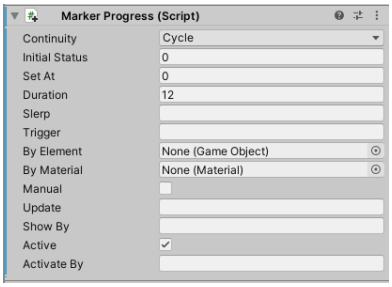


6.3 Walkable surfaces



Walkable surfaces are defined by adding a Marker Walk component to their game objects. The Visible field determines if they should be shown or not during the presentation.

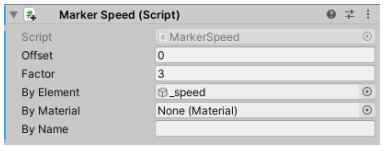
6.4 Progress



The Marker Progress component controls most of the progress of an element. Its fields are:

- **Continuity**: the continuity mode (Stop, Cycle, or Reverse) of the progress.
- **Initial status**: this tell Tames that when the model is loaded in Unity, where the progress initially was at.
- **Set at**: this sets the progress value at the start of Play mode
- **Duration**: the duration of progress in seconds
- **Slerp**: the lerping of the progress change.
- ~~**Speed factor**, **offset**, and **update (by element**, and **by name**): this allows that the progress speed to be dynamic based on the progress of another element (set by element or its name). It works as: *Speed = speed offset + (speed factor x base progress)*~~
- **Trigger**: the trigger of the progress. If left empty or erroneous, it will be ignored.
- **By Element and By Material**: sets the update basis of the element based on another element.
- **Manual:** the update will be manual (with input devices)
- **Update:** the update basis of the element, if it is not defined by element or material. If the update is set to Manual, here the keys should be typed.
- ~~**Switching key**~~**Show By**: an input key that switches the visibility of the element once pressed.
- **Active**: if the element is active when the play mode begins
- **Activate By**: an input key that switches the active status of the element.

6.5 Variable speed



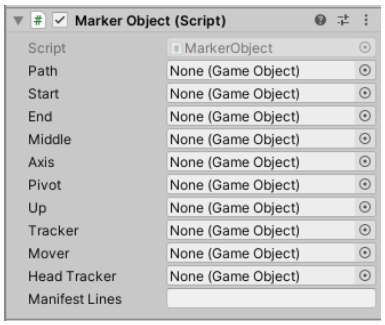
The Marker Speed component sets a range of speed for an element based on another element.

- **Offset**: the default speed in progress per second (i.e. when the base progress is 0). If this is set negative,

the default speed will be the element's own speed (set by Duration). Offset of zero means the element will stop at the base progress of 0.

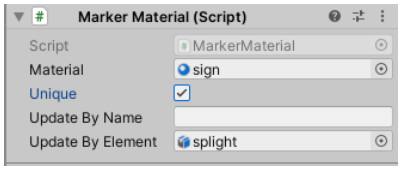
- **Factor**: the factor multiplied to the base progress. The final speed is calculated by the following: *Speed = offset + factor * base progress.*
- **By Element**, **Material** or **Name**: the base element.

6.6 Creating 3D elements



The Marker Object component allows you to set the necessary markers for defining interactive objects in Unity (instead of a 3D modeling application). While the naming requirements do not apply in this mode, the presence of certain markers (e.g., *start*) is the same as the import-based 3D elements. If the component is attached to an object that can pass as an element because of its 3D model, the markers in the component are prioritized in case of duplicate markers.

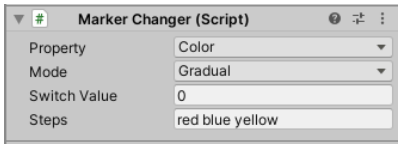
6.7 Materials and lights



The Marker Material component declares that a material is dynamic. It doesn't matter what object this component is attached to as long as it is a child of *interactives*.

- **Material**: the dynamic material (it should have at least one instance on descendants of *interactives* root object).
- **Unique**: if there are more than one instance of that material, copies of them are created to be treated individually. By doing that, the parent or update basis of each instance is automatically set to the closest dynamic ancestor of its holding mesh (if none found, to *time*).
- **update** (**by element**, and **by name**): for non-unique materials, this sets the update basis of the material.

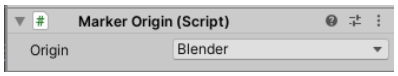
Lights do not require a designated component for them but there should be a Marker Progress component attached to them.



The properties of lights and materials are set by Marker Changer components (multiple components are allowed):

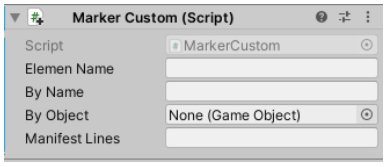
- **Property**: the property that should change.
- **Mode**: the changing mode (*stepped*, *gradual* or *switch*).
- **Switch value**: if mode is set as *Switch*, a value between 0 and 1 must be written here to work as the switch threshold.

- **Steps**: the list of steps (separated by space).



Because of a Unity issue, lights imported from Blender do not pass their children transforms correctly. Therefore, Tames need to correct this at the start of each Play session. If you have such a light (for example with an interaction area attached) in a Blender file, you need to use a Marker Origin component on the Blender's file's main object in the scene to let Tames know the model was created in Blender.

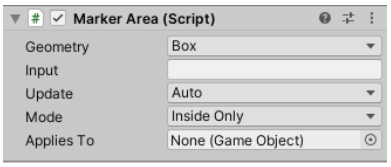
6.8 Custom elements



Custom elements are defined by adding a Marker Custom to any object under *interactives* (the object should not be defined as interactive by other components or model, and should not contain light):

- **Element name**: the name of the custom element (can be used as update basis of other elements).
- **By name** and **by element**: the update basis of this custom element.
- **Manifest lines**: custom manifest lines (advanced).

6.9 Interaction areas

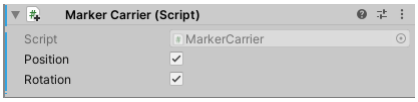


Interaction areas are better to be defined in the 3D model of their associated elements, but if this is not possible, you can add a Marker Area component to each element:

- **Geometry**: the intended shape of the interaction area (it should match the actual shape of the area). The options are Box, Cylinder, Sphere and Plane.
- **Input**: if the area is Switch mode, the key input here will act as its manual switch.
- **Update**: how the area should change by time. *Auto* mode is recommended.
- **Mode**: the mode that the interaction affects its attached element.
- **Applies to**: attaches the holder of this component as an area for a game object (that should be an interactive element). If no object is selected here, the area is attached to its holder's parent game object.

6.10 Camera carriers

A camera carrier is an object which defines the position and/or rotation of the camera. This object is defined by a Marker Camera. During the play mode, you can switch between carriers and the actual camera by pressing C:

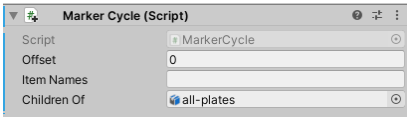


- **Position**: associates the position of the camera with this object. Once the carrier is active you can no longer walk. When the carrier is switched back

to the actual camera, you will be moved back to its position.

- **Rotation**: associates the rotation of the camera with this object. This option does not work during VR sessions. Once the carrier is active you cannot rotate the camera manually.

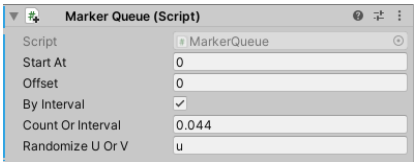
6.11 Cycled object sets



A cycled object set is an element that controls a collection of objects that iterate on a path. A sushi train or a luggage carousel are examples of this type of element:

- **Offset**: the distance between the last and first object on the path, relative to path's length.
- **Item Names**: the name of 3D objects to be cycled.
- **Children Of**: *all* children of the selected game object will be considered as cycled objects**.**

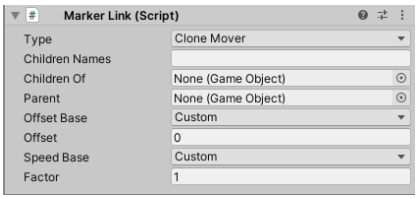
6.12 "Queued" object sets



A queued object set is an element whose moving part is cloned with an interval and all the clones move together. This is like the cycled objects with the difference that you only need to define one moving object. An example of this type of element is an escalator:

- **Offset**: the first obejct will be placed at this point (a number relative to the path's length).
- **By Interval**: if checked, the cloned objects will be placed by an interval (relative to the path's length)
- **Count or Interval**: the count of clones or the distance between them (if By Interval is checked, the count is calculated automatically).
- **Randomize U or V**: To make the clones less monotone, you can randomize the UV offset of its materials by either u or v (or x or y)**.**

6.13 Linked objects

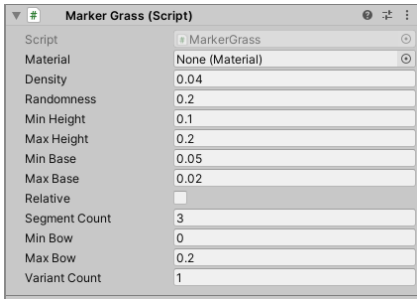


Linked objects are ordinary objects which turn into dynamic objects based on their link to a predefined interactive object. Currently, Tames only allow 3D object to be linked. There are three ways to create a linked object: a full clone, a mover clone and a motion clone (mover link). A full clone creates a copy the whole of element with all its children (whether moving or not) and interaction areas and progress. The created copy is located and orientated by the linked object. A mover clone is similar to the former but the none-moving children are not cloned. In both types, the clones can act independent of the original object. A mover link only applies the movement of the object to the linked objects. Therefore, the linked objects

move as the original changes. The linking is defined by a Marker Link component.

- **Type**: the type of linkage (clone mover, clone everything and link mover)
- **Children names**: the name of linked objects. Only to be filled if the component is attached to the original object.
- **Children of**: linked objects are all the children of this gameobject. Only be filled if the component is attached to the original object
- **Parent**: The game object corresponding to the original object. Only use this on the linked objects.
- **Offset base**: how the offset of progress value for the clones is calculated. The options are *Custom*, *Random*, and by *Parent* (same as original).
- **Offset**: the value of offset (only works if the offset base is set to *Custom*.
- **Speed base**: how the speed of the clone's progress is defined. The options are same as above.
- **Factor**: a value that is used to calculate the duration of clone's progress. This works differently for each *Speed base* type. For *Custom*, the value will be the progress' duration. For *Random*, a random duration is set between *Factor*/3 and *Factor**3. For *Parent*, the duration is set to the parent's duration, multiplied by *Factor*.

6.14 Grass



It is possible to create grass-covered surfaces by Tames. The standard procedure is to use Unity's terrain but Tames' grass may be handier for those who are not familiar with Terrains. The position of grass pieces are calculated based on a grid, that is defined by the average distance between adjacent plants. The grid is created on a flat horizontal plane and then projected vertically on the designated surface. The use can define the dimension range of the leaves, their bending, segment count and material. These are set in Marker Grass component.

- **Material**: the grass leaf material. The material can have different variants of grass which are arranged horizontal after each other (so their U values are different). Tames randomly select one section of the material's texture for each leaf.
- **Density**: the distance between each piece of grass (in metres).
- **Randomness**: sets how randomly the grass are planted. The randomness of 0 means the plants are

placed exactly on the grid points. Higher numbers indicate the maximum distance (relative to the density value). For example, 0.5 means the possibility 50% distance to the grid points.

- **Min** and **Max Height**: The minimum and maximum possible height of a leaf (in meter). The height for each leaf is calculated randomly.
- **Min** and **Max Base**: The minimum and maximum possible width of the base of a leaf (in meter). The leaves are pointy so their tip's width is always zero.
- **Relative**: Checking this means the base width of a leaf is calculated relative to its height. So, a 15cm-high leaf cannot have the max. base width if the max height is 20cm. Instead, its max. possible base width will be 75% of the max. base value.
- **Segment count**: the number of segments in the Y axis of the triangular outline of a leaf. The value of 1 means a plain triangle. Higher numbers create a realistic bent appearance but also increase the computational load.
- **Min** and **Max Bow**: determines how bent the leaves are. The value is relative to the height of leaves.
- **Variant count**: the number of variants of grass leafs. To make this work properly, the material texture should be accurately divided into this count, horizontally.

~~7 Examples~~