Forget Keyframing - Take Real-Time Control of your Animated Assets with 3dsMax  GA124600

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Brian-proof (ing) — (verb)
1. Anticipating the last second change.
Brian-proof (ing) – (verb)

1. Anticipating the last second change.
2. Adapting to the last second change.
1. Anticipating the last second change.

2. Adapting to the last second change.

3. Winning the last second change.
Learning Objective 1 - The Right Tools & Techniques for The Job

Learning Objective 2 - The 5 P’s

Learning Objective 3 – Expression Controllers

Learning Objective 4 – Rigging the Remote Control
Learning Objective 1 - The Right Tools & Techniques for The Job
Various Animation Techniques

- **Keyframing**
  
  A specific point along the timeline that defines a specific value or parameter of an object's transition.
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- **Procedural Animation Modifiers**
  A modifier added to a modifier stack of your object that can control specific parameters unique to that modifier. You can stack these modifiers layered effects.

**Example:** Stacked Procedural Modifiers
Various Animation Techniques

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- **Procedural Animation Modifiers**
  A modifier added to the modifier stack of your object that can control specific parameters unique to that modifier. You can stack these modifiers for layered effects.

- **Animations Controllers**
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Learning Objective 2 – the 5 P’s
Proper Planning Prevents Poor Performance
The Importance of Proper Setup and Organization

- Understand goal of end result and imagine potential pitfalls
- Logical naming conventions
- Pivot Points
- Hierarchy
- Appropriate coordinate System
- Linking to Dummy Objects
The Baseline – Simple Ceiling Fan

- Live Demo 1 (based on class response to experience)
  - Link and align ceiling fan components
  - Create dummy object
  - Group and array fan blade component
  - Keyframe simple rotation along the Z axis
  - Assign Out of Range Controller
  - Demonstrate how to modify the keyframes
Learning Objective 3 – Expression Controller
Example of a model with many simple animated elements. Although, individually these motions are simple, collectively they become more difficult to manage and edit.
Expression Controllers
Expression Controllers – Example 1

Create Variables
Name: Speed  [Scalar]
[Create] [Delete] [Rename]

Variable Parameters
Tick Offset: 0

Scalars
Speed

Vectors

Expression
S*Speed*-360*pi/360

Description
Function List
T = ticks  F = frames
S = secs  NT = normalized time

Assigned to: Constant: 0.1
[Assign to Constant] [Assign to Controller] [Save] [Load] [Debug] [Evaluate] [Close]
Simplicity Compounded– The Air Racer

- Live Demo 2 – harnessing the tentacles
  - Verify links and hierarchy
  - Access appropriate axis through motion panel
  - Assign simple expression controller and demo
  - Create and introduce the variable, assign value and demo
  - Rinse...repeat for all dummy objects on one arm and Demo
  - Open final rigged version and (segue) demo the remote control
With proper planning, even complex systems can be tamed rather quickly...
Centrifugal Force

Time derivatives in a rotating frame \[ \frac{d}{dt} \]

In a rotating frame of reference, the time derivatives of any vector function \( \mathbf{F} \) of time—such as the velocity and acceleration vectors of an object—will differ from its time derivatives in the stationary frame. If \( \mathbf{F}_1, \mathbf{F}_2, \mathbf{F}_3 \) are the components of \( \mathbf{F} \) with respect to unit vectors \( \mathbf{u}_1, \mathbf{u}_2, \mathbf{u}_3 \) directed along the axes of the rotating frame, then the first time derivative \( \frac{d}{dt}(\mathbf{F}_1) \) of \( \mathbf{F} \) with respect to the rotating frame is, by definition, \( \frac{d}{dt}(\mathbf{F}_1) = \frac{d}{dt} \mathbf{F}_1 + \mathbf{u}_1 \times \frac{d}{dt} \mathbf{F} \). If the absolute angular velocity of the rotating frame is \( \mathbf{\Omega} \), then the derivative \( \frac{d}{dt}(\mathbf{F}_1) \) with respect to the stationary frame is related to \( \frac{d}{dt} \) by the equation:

\[
\frac{d}{dt} \mathbf{F} = \frac{d}{dt} \mathbf{F}_1 + \frac{d}{dt} \left( \mathbf{F}_1 \right) \times \mathbf{\Omega}.
\]

where \( \times \) denotes the vector cross product. In other words, the rate of change of \( \mathbf{F} \) in the stationary frame is the sum of its apparent rate of change in the rotating frame and the rate of rotation \( \omega = \mathbf{\Omega} \times \mathbf{F} \) attributable to the motion of the rotating frame. The vector \( \mathbf{\omega} \) has magnitude \( \omega \) equal to the rate of rotation and is directed along the axis of rotation according to the right-hand rule.

Acceleration \[ \text{[edit]} \]

Newton's law of inertia for a particle of mass \( m \) in a rotating frame is:

\[
\mathbf{F} = m \mathbf{a},
\]

where \( \mathbf{F} \) is the vector sum of the forces applied to the particle and \( \mathbf{a} \) is the absolute acceleration (that is, acceleration in an inertial frame) of the particle, given by:

\[
\mathbf{a} = \frac{d^2 \mathbf{r}}{dt^2}.
\]

where \( \mathbf{r} \) is the position vector of the particle.

By applying the transformation above from the stationary to the rotating frame three times, the absolute acceleration of the particle can be written as:

\[
\mathbf{a} = \frac{d^2 \mathbf{r}}{dt^2} = \frac{d}{dt} \left( \frac{d}{dt} \right) \mathbf{r} = \frac{d^2}{dt^2} \mathbf{r} + \frac{d}{dt} \mathbf{r} \times \mathbf{\Omega} + \mathbf{r} \times \left( \frac{d}{dt} \mathbf{\Omega} \right).
\]

Force \[ \text{[edit]} \]

The apparent acceleration in the rotating frame is \( \mathbf{a} = \frac{d^2 \mathbf{r}}{dt^2} \). An observer unaware of the rotation would expect this to be zero in the absence of outside forces. However, Newton's law of inertia applies only in the inertial frame and describe dynamics in terms of the absolute acceleration of \( \mathbf{r} \). Therefore, the observer perceives the extra terms as contributions due to fictitious forces. These terms in the apparent acceleration are independent of mass, so it appears that each of these fictitious forces, like gravity, pulls on an object in proportion to its mass. When these forces are added, the equation of motion in the frame is:

\[
F = \frac{d}{dt} \left( m \frac{d \mathbf{r}}{dt} \right) = m \frac{d^2 \mathbf{r}}{dt^2} = m \left( \frac{d^2 \mathbf{r}}{dt^2} + \mathbf{\Omega} \times \frac{d \mathbf{r}}{dt} + \left( \frac{d}{dt} \mathbf{\Omega} \right) \times \mathbf{r} \right).
\]

From the perspective of the rotating frame, the additional force terms are experienced just like the real external forces and contribute to the apparent acceleration. The additional terms on the force side of the equation can be recognized as:

\[
F = m \left( \frac{d^2 \mathbf{r}}{dt^2} + \omega \times \frac{d \mathbf{r}}{dt} + \frac{d}{dt} \left( \omega \times \mathbf{r} \right) \right).
\]

The apparent force is a fictitious force. It is independent of the mass of the particle and the rotation of the frame of reference. It is a result of a rotating frame. As expected, for a non-rotating inertial frame of reference (\( \omega = 0 \)), the centrifugal force and all other fictitious forces disappear.
Centrifugal Force

Time derivatives in a rotating frame

In a rotating frame of reference, the time derivatives of vectors such as $\mathbf{P}$, $\mathbf{r}$, and $\mathbf{v}$ will differ from their time derivatives in the stationary frame. If $P_1$, $P_2$, $P_3$ are the components of $\mathbf{P}$ with respect to unit vectors $\mathbf{i}$, $\mathbf{j}$, $\mathbf{k}$, then the time derivative of the components of the rotating frame is related to the stationary frame by $\mathbf{dP}/\mathbf{dt} = \omega \times \mathbf{P}$.

where $\omega$ denotes the vector cross product. In other words, the rate of change of $\mathbf{P}$ in the stationary frame is the vector sum of the apparent rate of change in the rotating frame and the rate of rotation $\mathbf{w} \times \mathbf{P}$ attributable to the motion of the rotating frame.

The vector $\mathbf{w}$ has magnitude equal to the rate of rotation and is directed along the axis of rotation according to the right-hand rule.

Acceleration

Newton's law of motion for a particle of mass $m$ in stationary frame is:

$$ \mathbf{F} = m \mathbf{a}, $$

where $\mathbf{F}$ is the vector sum of the physical forces applied to the particle and $\mathbf{a}$ is the acceleration (that is, the time derivative of the velocity) of the particle, given by:

$$ \mathbf{a} = \frac{\mathbf{d}\mathbf{v}}{\mathbf{dt}}. $$

By applying the information above from the stationary to the rotating frame three times, the absolute acceleration of the particle can be written as:

$$ \mathbf{a} = \frac{d^2\mathbf{r}}{dt^2} + \frac{d\mathbf{v}}{dt} \times \mathbf{\omega} $$

Force

The apparent acceleration in the rotating frame is $\mathbf{a} = \mathbf{a} + \mathbf{w} \times \mathbf{r}$. As observer unaware of the rotation would expect this to be zero in the absence of outside forces. However, Newton’s laws of motion apply only in the inertial frame and describe dynamics in terms of the absolute acceleration of $0$. Therefore, the observer perceives the extra terms as contributions due to fictitious forces. These terms in the apparent acceleration are independent of mass, so it appears that each of these fictitious forces, like gravity, acts on an object in proportion to its mass. When these forces are added, the equation of motion takes the form:

$$ \mathbf{F} = \mathbf{w} \times \mathbf{r} - 2m\mathbf{\omega} \times \frac{d\mathbf{r}}{dt} - m\mathbf{\omega} \times (\mathbf{\omega} \times \mathbf{r}) = m \frac{d^2\mathbf{r}}{dt^2} \mathbf{,}. $$

From the perspective of the rotating frame, the additional force terms are experienced just like the real external forces and contribute to the apparent acceleration. The additional terms on the force side of the equation can be recognized as moving from left to right, the Euler force $-m\mathbf{w} \times \mathbf{r}$, the Coriolis force $-2m\mathbf{\omega} \times \frac{d\mathbf{r}}{dt}$, and the centrifugal force $-m\mathbf{\omega} \times (\mathbf{\omega} \times \mathbf{r})$, respectively. Unlike the other two fictitious forces, the centrifugal force always points radially outward from the axis of rotation of the rotating frame, with magnitude $m\mathbf{\omega}^2r$, and unlike the Coriolis force in particular, it is independent of the mass of the particle in the rotating frame. As expected, for a non-rotating inertial frame of reference ($\mathbf{\omega} = 0$), the centrifugal force and all other fictitious forces disappear.
Faking Centrifugal Force

In a rotating frame of reference, the time derivatives of a vector quantity $P$, such as the velocity and angular velocity, with respect to unit vectors $\hat{e}_1$, $\hat{e}_2$, and $\hat{e}_3$ in terms of the rotating frame differ from their time derivatives in the stationary frame. If $P_1$, $P_2$, $P_3$ are the components of $P$ with respect to the rotating frame, then the velocity $\hat{v}$ of an object will differ from its time derivatives in the stationary frame, defined by $\hat{v}$, $\hat{\omega}$, $\hat{\omega}_d$. The first time derivative $[\hat{D}P]/dt$ of $P$ in the rotating frame is equal to its derivative with respect to the stationary frame $[\hat{D}P]/dt$ related to $[\hat{D}P_0]/dt$ by the vectors $\hat{v}$ and $\hat{\omega}_d$ of $P$ with respect to the rotating frame $\hat{v}$, as defined, $\hat{D}P/\hat{D}t = \hat{D}P_0/\hat{D}t + \hat{v} \times P_0 + \hat{\omega}_d \times P_0$.

Acceleration

Newton's law of inertia for a particle of mass $m$ in a stationary frame is:

$$F = ma$$

where $F$ is the vector sum of the physical forces applied to the particle and $a$ is the absolute acceleration (that is, the acceleration of the center of mass) of the particle, given by:

$$a = \frac{d\hat{r}}{dt}$$

where $\hat{r}$ is the position vector of the particle.

By applying the transformation above from the stationary frame to the rotating frame three times, the absolute acceleration $a$ of the particle can be written as:

$$a = \frac{d\hat{r}}{dt} + \hat{v} \times \frac{d\hat{r}}{dt} + \hat{\omega}_d \times \frac{d\hat{r}}{dt} = \frac{d\hat{r}}{dt} + \hat{v} \times \frac{d\hat{r}}{dt} + \hat{\omega}_d \times \frac{d\hat{r}}{dt}$$

Force

The apparent acceleration in the rotating frame is $[\hat{D}P]/d\hat{t}$. An observer unaware of the rotation would expect this to be zero in the absence of outside forces. However, Newton’s laws of motion apply only in the inertial frame and describe dynamics in terms of the absolute acceleration of $\hat{v}$. Therefore, the observer perceives the extra terms as contributions due to fictitious forces. These terms in the apparent acceleration are independent of mass, so it appears that each of these fictitious forces, for example, pushes an object in proportion to its mass. When these forces are added, the equation of motion has the form $[\hat{D}P]/dt = \hat{F}$. From the perspective of the rotating frame, the additional force terms are experienced just like the real external forces and contribute to the apparent acceleration $[\hat{D}P]/dt = \hat{F}$.

The additional terms on the force side of the equation can be recognized as moving from left to right, the Euler force $= \hat{v} \times \hat{F}$, the Coriolis force $= -2\hat{\omega}_d \times \hat{v}$, and the centrifugal force $= \hat{\omega}_d \times \hat{\omega}_d \times \hat{v}$. Unlike the other two fictitious forces, the centrifugal force always points radially outward from the axis of rotation of the rotating frame, with magnitude $m\hat{r}^2\hat{\omega}$, and unlike the Coriolis force in particular, it is independent of the motion of the particle in the rotating frame. As expected, for a non-rotating inertial frame of reference ($\hat{\omega} = 0$) the centrifugal force and all other fictitious forces disappear.
Faking Centrifugal Force

Charts and graphs are now a functioning part of the Autodesk University template. Not liking the chart? Change it up in the Chart Design Type tab, click Reset if modules do not look correct.
Faking Physics– The Wave Swinger

- Live Demo 3 – Faking Physics
  - Verify links and hierarchy
  - Create IK chain
  - Access goal object through motion panel
  - Assign expression controller, add variables and demo
  - Rinse...repeat for all dummy objects on one arm.
  - Open final rigged version and (segue) demo the remote control
Learning Objective 4 – There’s a remote for that
Setting up the ‘remote’

- Attribute Holder modifier
Setting up the ‘remote’

- Attribute Holder modifier
Setting up the ‘remote’

- Attribute Holder modifier
- Parameter Editor
Setting up the ‘remote’

- Attribute Holder modifier
- Parameter Editor
Setting up the ‘remote’

- Attribute Holder modifier
- Parameter Editor
- Wiring
Putting Batteries in the Remote – The Wave Swinger

- Live Demo 4 – “Brian-proofing”
  - Verify links and hierarchy
  - Introduce The Attribute holder modifier (what do we need to control)
  - Introduce the Parameter Editor
  - Create our custom attributes
  - Link/wire parameters to all controllers and demo
  - Open final rigged version and demo the remote control
The Virtual Remote Control