**How to use the 3D stackable brick keyframe animator**

**1. Getting Started**

Before running this program, ensure that the most up-to-date versions of jPCT (a n open source 3D engine/API for java) and LDraw (a freeware program/database of LEGO pieces) are installed. Then, depending on how the java files are installed, run the main method found in BrickViewer.java, optionally with an argument telling it the name of a brick file to open. For example, the file 2357.dat will load in the 2x2 corner piece. A comprehensive list of all the bricks available can likely be found in the LDraw installation.

If no arguments are given, the program will open a dialog box where the desired brick or model can be chosen. As of the current version, this will be duplicated and shown twice. When a model has been successfully loaded, three windows will show. The top left window is the Adjustment Panel, the bottom left window is the Frame Preview Panel, and the right window is the Rendering Area.

**2. Basic Controls**

**2.a Camera Controls**

As of this version, camera controls are fairly bulky and difficult to master. The two ways to maneuver the camera are by editing its position in the Adjustment Pane and by clicking and dragging in the Rendering Area. The Adjustment Pane can only edit the camera's position, as adjusting the facing of the camera (its direction vector) is difficult to manage in any intuitive way. To that extent, these values are purely informative.

In each text field under "Camera Position," the values can be changed by either typing in a new value or hitting the up or down arrow keys. The arrow keys will change it by incrementing or decrementing the current value by one. However, if the control (Ctrl) key is held down, these will increment or decrement the value by ten, and if shift is held, the value is only changed by 0.1.

**2.b Brick Selection and Controls**

There are two ways to select a brick that has been rendered, and both ways are currently independent of the other. The first is to use the Adjustment Pane's "Edit Object Parameters" field. The first box is the index of the currently selected brick, the next three show its current position, and the final box shows its colors. As with the fields concerning the camera, each can be edited either by typing in a new value or using the up and down arrows. When editing the brick's position, control and shift can be held down to change how much the up and down arrows change the current value.

Also in the Adjustment Pane are several buttons that control the currently selected brick's translation and rotation. Each button affects the brick as it is labeled according to the brick's *internal X/Y/Z vectors.* This is the expected behavior, but is important to note as these vector do shift with the brick. Rotation using the buttons is in forty-five degree increments, as these seem most useful for building and keyframing. Holding control while clicking any of these buttons performs the opposite action.

The "Add new brick" and "Redo last add" buttons do what they say: The first opens a window with a preview pane for selecting a brick file to import while the second imports the most recently opened file. All new bricks currently start out with a color code of 0 for black, but can be changed easily as they are added to the end of the brick list, so their ID is the highest. Right now, the 100000 polygon limit allows for only 30 bricks per scene, but this does not apply to bricks imported but moved off-camera.

Bricks can also be selected by clicking them in the Rendering Area. This will 'highlight' selected bricks by rendering them as grey with a black outline. Simply clicking a brick selects it and deselects any other bricks that were selected. Clicking a brick while holding down control will select it without deselecting other bricks, and clicking a selected brick while holding control deselects that brick.

When multiple bricks are selected, they rotate and translate together. The first selected brick is the 'root' brick, which simply means that all rotations will be centered around its center. Deselecting the root brick makes the second brick that was selected the new root. Bricks that are selected as part of a group selection can be modified individually through the Adjustment Pane except for the root brick itself.

With the Rendering area as the active window, several keyboard shortcuts work for translations, rotations, and scaling. U and I rotate the selected (highlighted) brick(s) along the X-axis of the root, J and K rotate the selected brick(s) along the Y-axis of the root, and M and , (the comma key) rotate the selected brick(s) along the Z-axis of the root. If a number pad is present, then the following keyboard shortcuts also work. 8 and 2 translate the selected bricks along the world's Y-axis (up and down), 4 and 6 translate the selected bricks along the world's Z-axis (left and right), 0 and 5 translate the selected bricks along the world's X-axis (to and from the camera), 1, 3, 7, and 9 act as a combination of the two buttons to which they are closest (for example, 1 would move a selected brick down and to the left), and the + and - (plus and minus) keys scale the objects to be larger and smaller by a factor of 1.1. Holding control while hitting any keys to translate a brick moves it ten units in that direction.

**3. Keyframes and Movies**

To make a movie, you first need to make several keyframes. To make a keyframe, simply arrange the bricks as desired, and hit the "Take Frame" button on the Adjustment Pane. To edit an existing keyframe, navigate to it using the First, Previous, Next, and Last buttons on the Frame Preview Panel, and click the "Restore Last Frame" button on the Adjustment Pane. This changes the contents of the Rendering Area to match the currently displayed frame, which can then be edited. Save these changes as a new frame and delete the old one. If needed, change the order of the frame using the "Swap left" and "Swap right" buttons on the Frame Preview Panel. The Duplicate button duplicates the current frame and places the new version directly after it.

Clicking the "Save Frame" button automatically saves the currently displayed frame in the default directory as "frame\_#.kf", where # is the frame's current position. "Open Frame" does as it is labeled, opening a dialog box to select a previously saved keyframe file. The selected file is then loaded as a new keyframe and added to the end of the current list of frames.

To play a movie, click the Play button on the Adjustment Pane, and the program will cycle through all of the current frames in order. To save a movie, which will consists of all of the frames currently open, click the "Save Movie" button and enter a name for it (without any periods) in the dialog box. It will be saved in the default directory as "<name>.kfm." Opening a saved movie is intuitive, but it is important to note that an opened movie will replace all current frames, so be sure to save any work that might be lost.

It is important to note that several things will be set with the first frame. This includes the color of all current bricks (changing the colors in future frames does not appear in the movie), the camera angle (camera interpolation does not currently work), and the number of brick to be shown (there is code to support adding new bricks, but none at all to support removing bricks. Instead, to remove a brick, send it to <-10000, -10000, -10000>, where it will most likely not be seen).

It is also important to note that the "Frame Settings," "Movie Settings," and "Brick Settings" portions of the Frame Preview Panel are either empty or do not currently work. Also, the program suffers from severe memory leaks. Newly rendered and discarded BrickObjects do not get properly garbage collected, so flipping through frames very quickly pushes up the memory usage to a very high level.