



# Introduction to Computer Graphics

## 2. Transformations (B)

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*Textbook: E.Angel, Interactive Computer Graphics, 5th Ed., Addison Wesley*

*Ref:Hearn and Baker, Computer Graphics, 3rd Ed., Prentice Hall*

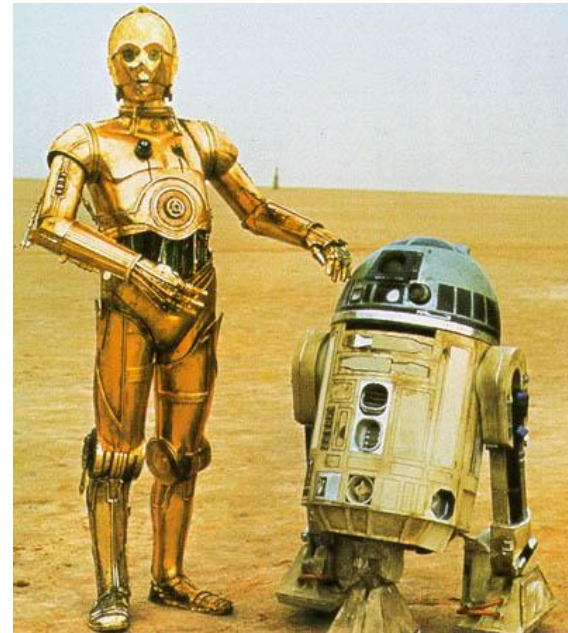
# Hierarchical structure

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- In addition to separate instances, plenty of objects consist of hierarchical sub-components , e.g. skeletons, desk lamps, excavators, etc.



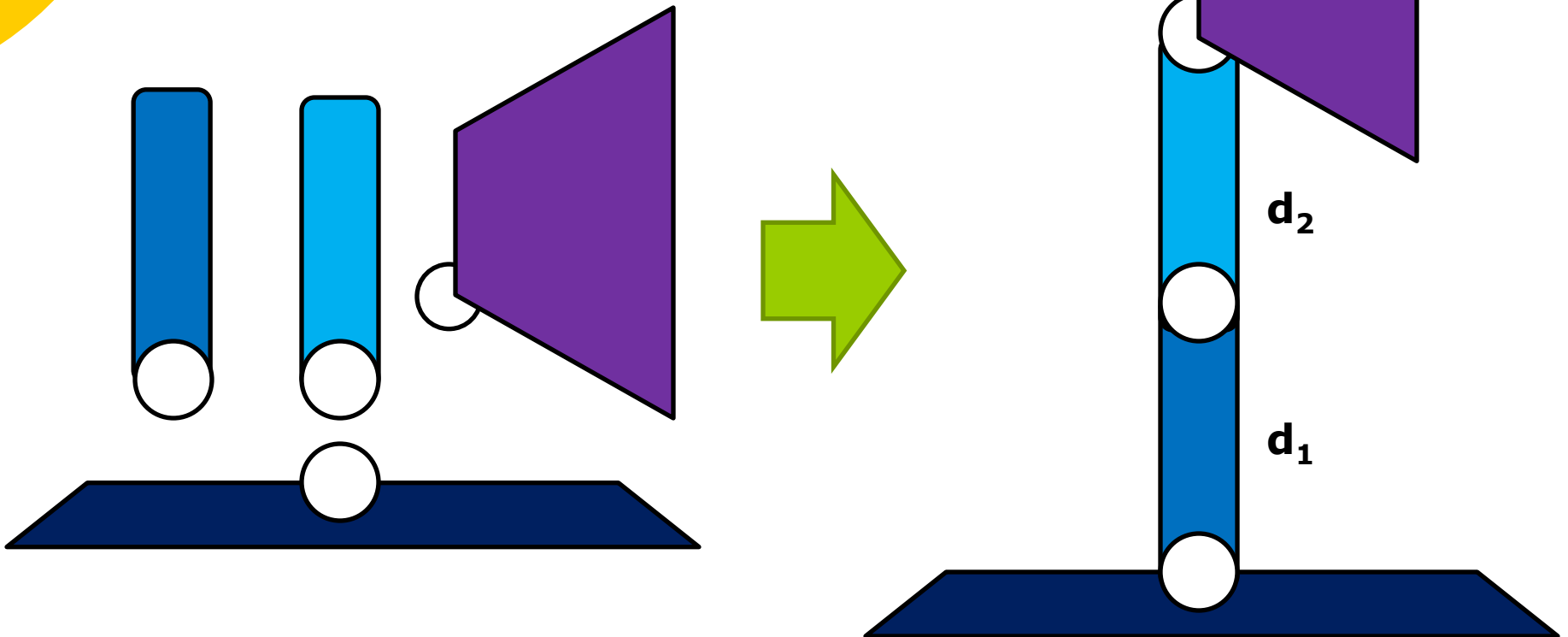
Luxo, Pixar



C3PO and R2D2, star wars

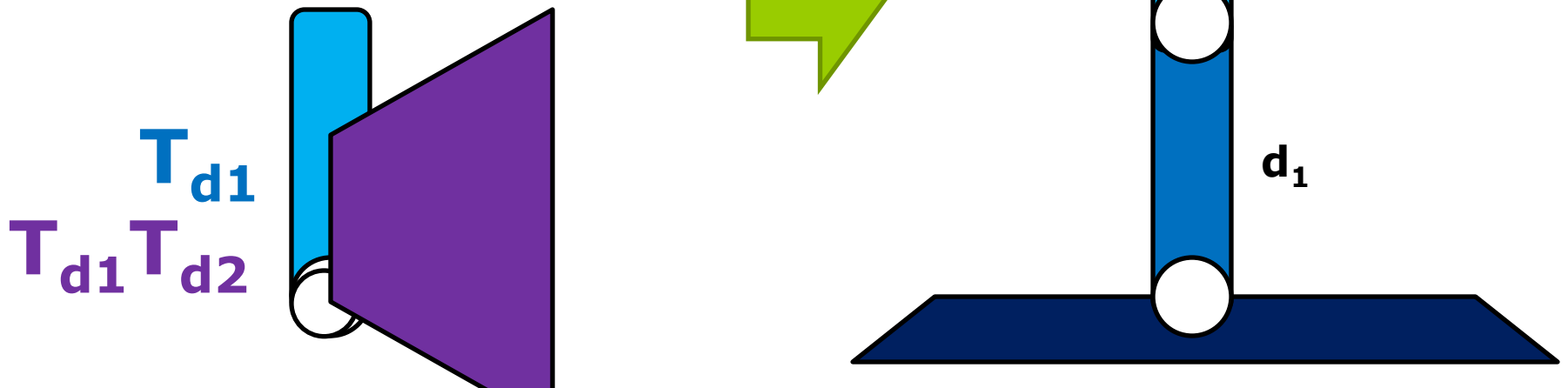
# Hierarchical structure (cont.)

- How to represent the transformation of such hierarchical structure?



# Hierarchical structure (cont.)

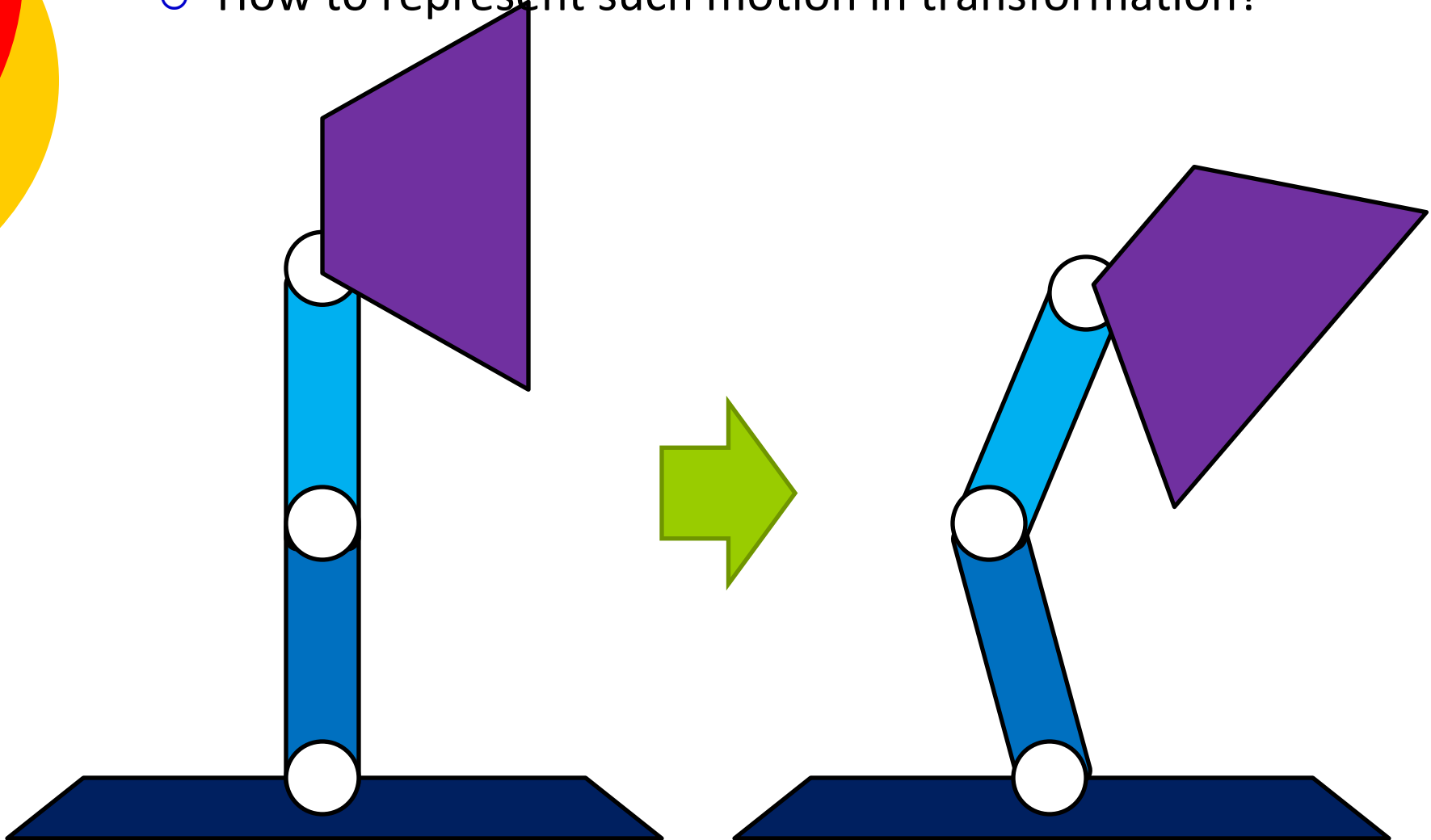
- Assume circles are the origin of local coordinates.



# Hierarchical structure (cont.)

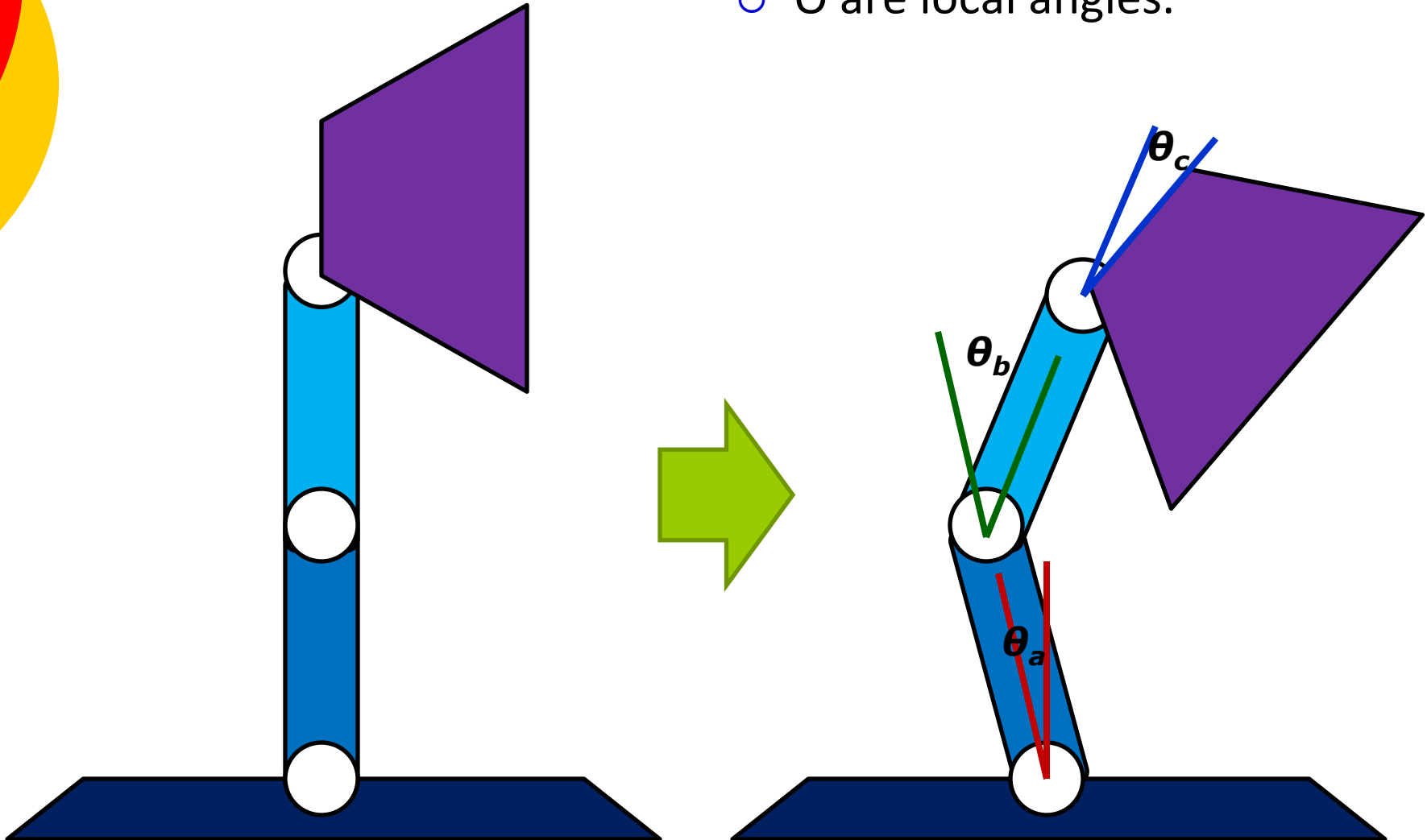
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- How to represent such motion in transformation?



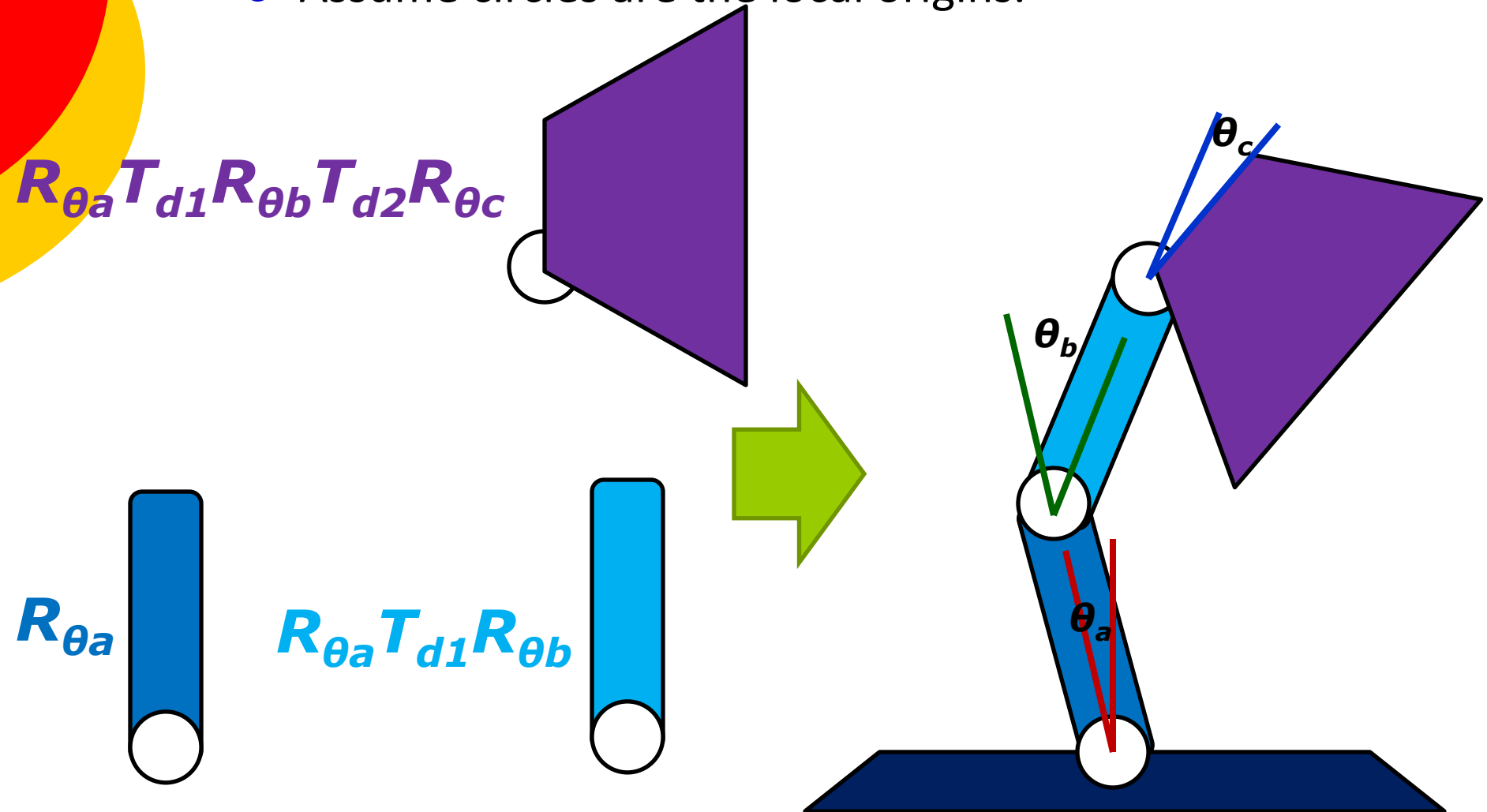
# Hierarchical transformation

- $\Theta$  are local angles.



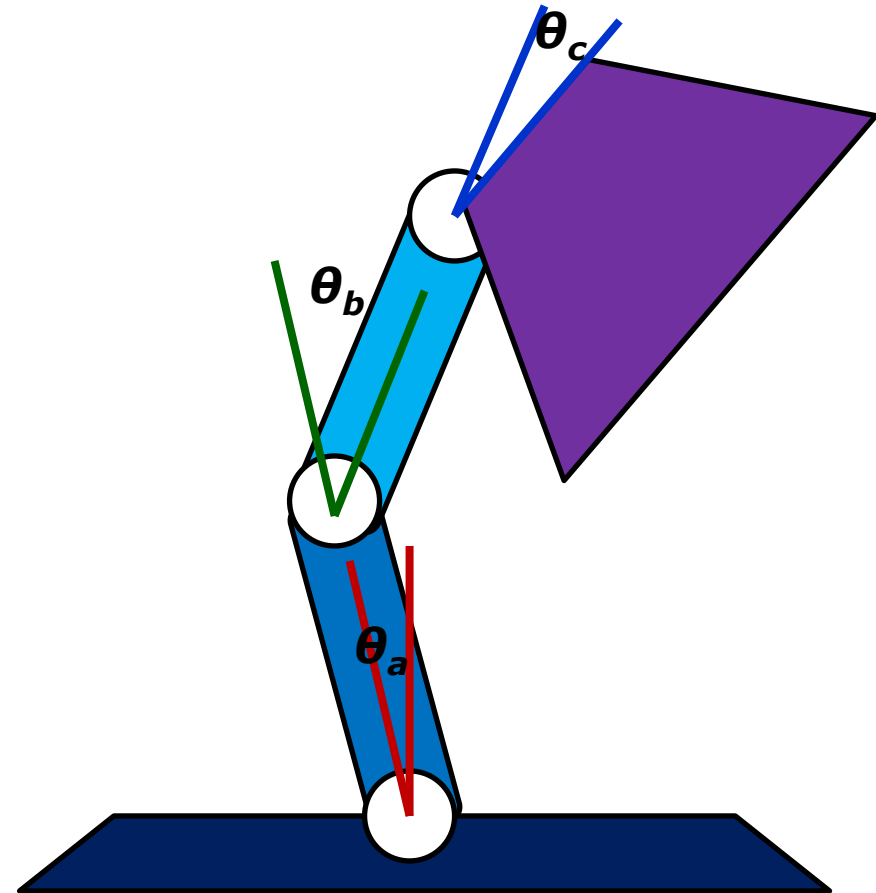
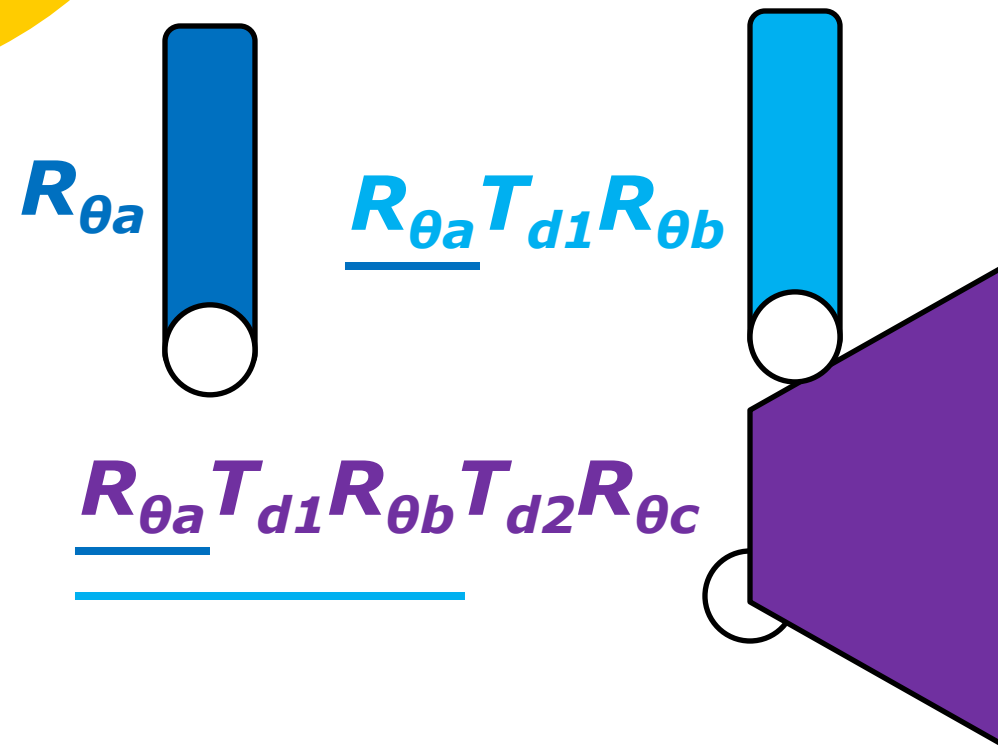
# Hierarchical transformation (cont.)

- Assume circles are the local origins.



# Hierarchical transformation (cont.)

- There are common sub-transformation.
- We can avoid redundant matrix multiplication by stack mechanism.
  - Hierarchical coordinates.





# Matrix in OpenGL style

.....  
“Draw the base”

```
glRotate( $\theta_a$ );  
glPushMatrix();
```

“Draw the dark blue arm”

```
glPopMatrix();  
glTranslate( $d_1$ );
```

```
glRotate( $\theta_b$ );  
glPushMatrix();
```

“Draw the light blue arm”

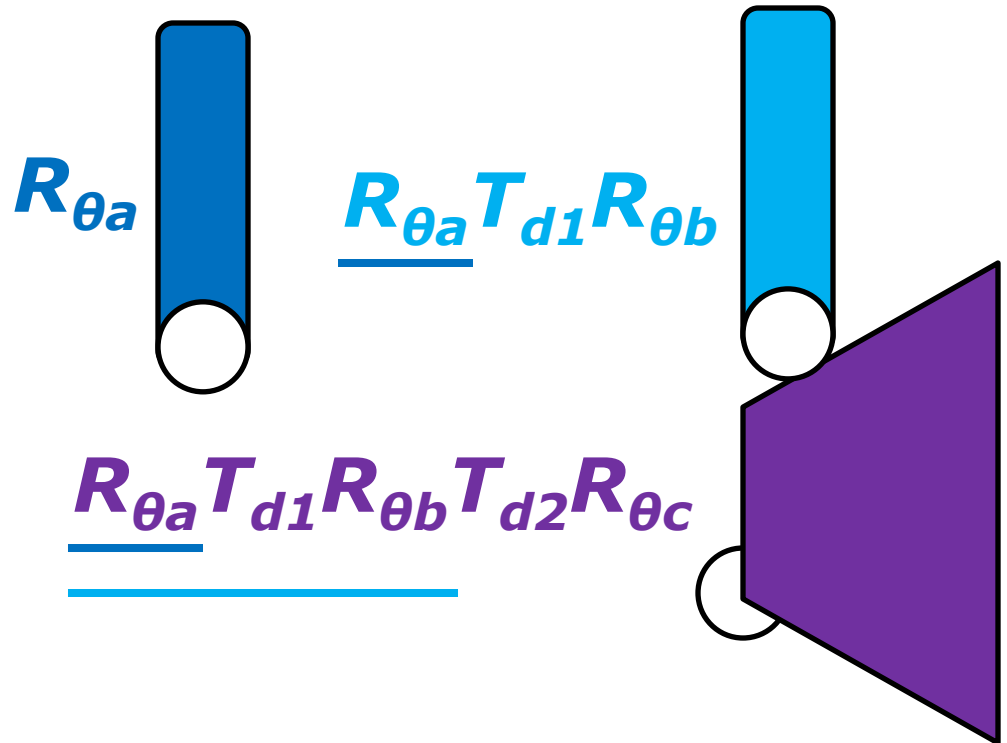
```
glPopMatrix();  
glTranslate( $d_2$ );
```

```
glRotate( $\theta_c$ );  
glPushMatrix();
```

“Draw the lampshade”

```
glPopMatrix();
```

.....



*How to deal with branches?*