Computer Graphics

Tue, July 14 (Week 4)

Graphics and Vision

They are both

- Essential to make AR work
- Quite complicated (intro courses being CS junior-level)

Our Goal: Learn some terms and basics

Computer Graphics

The case of our interest:

> Converting a virtual world with virtual objects into pixels of a screen.

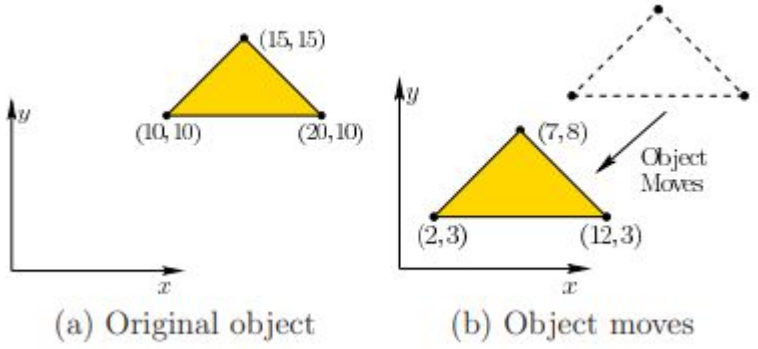
Virtual World:

> A space with objects inside it.

Translation, Rotation, and Scaling

The 3 ways an object moves in a 3D scene.

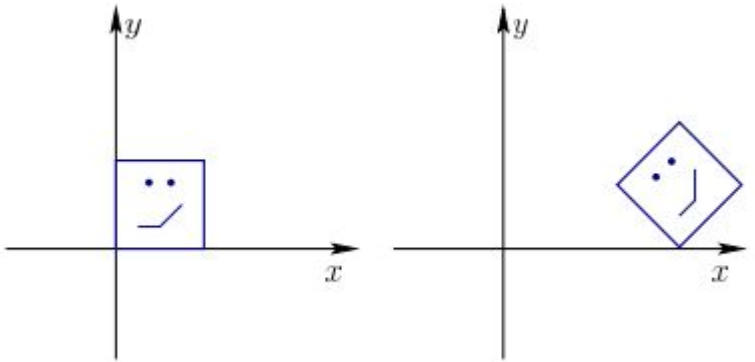
Translation:



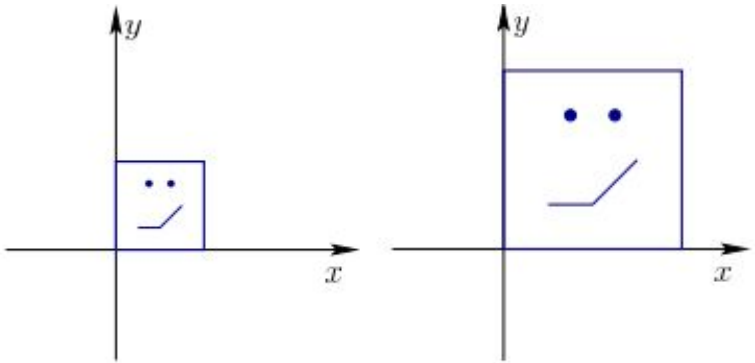
(a) Original object (b) Object moves

Translation, Rotation, and Scaling

Rotation:



Scaling:



$$\begin{bmatrix} 2 & 0 \\ 0 & 2 \end{bmatrix}$$

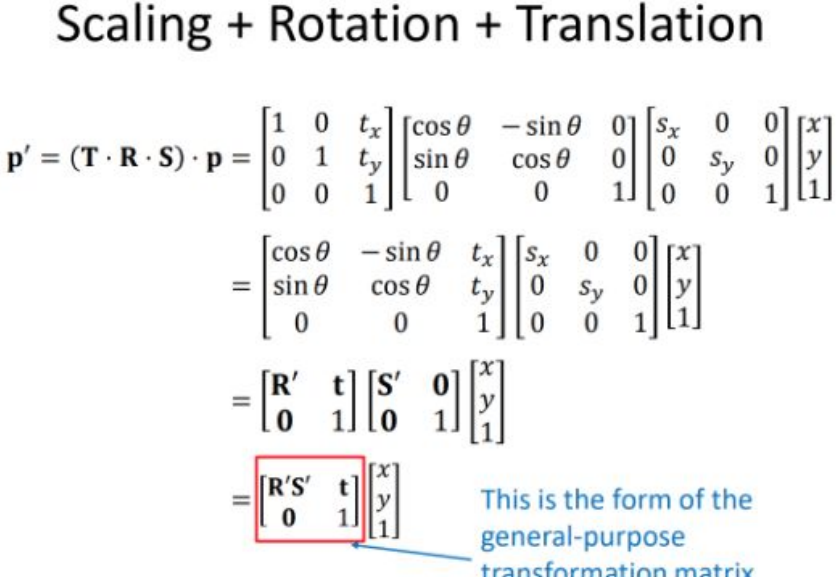
TRS

TRS Matrix:

Translation, Rotation, and Scaling in a single matrix

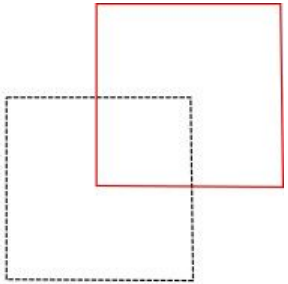
The reason why those 3 were chosen.

: representation in a single matrix

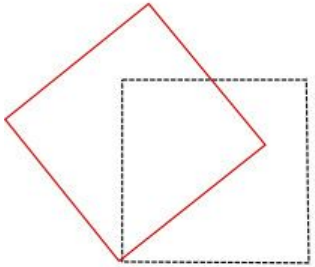


TRS

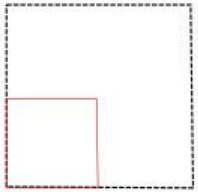
Original



Translation

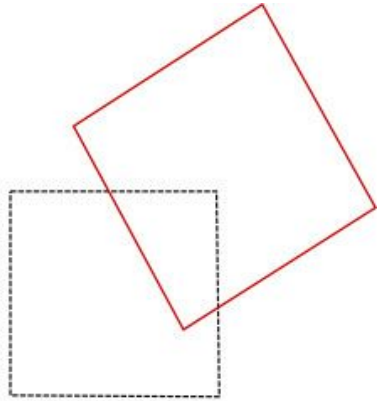


Rotation

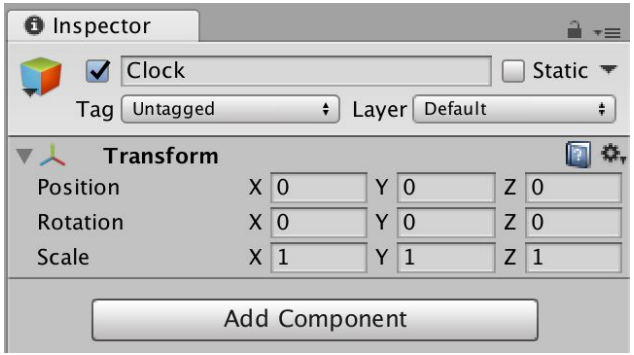


Scaling

Original



Translation, Rotation and Scaling



Hierarchy

Two ways to describe this scene

1. There is a desk on the floor and a laptop 1 m away from the floor.
2. There is a desk on the floor and a laptop on top of the desk.

Hierarchy

Two ways to describe this scene

1. There is a desk on the floor and a laptop 1 m away from the floor.
2. **There is a desk on the floor and a laptop on top of the desk.**

Hierarchy

Two ways to numerically describe this scene

1. A TRS for the desk and a independent TRS for the laptop.
2. **A TRS for the desk and a TRS for a laptop considering it is on the desk.**

Hierarchy

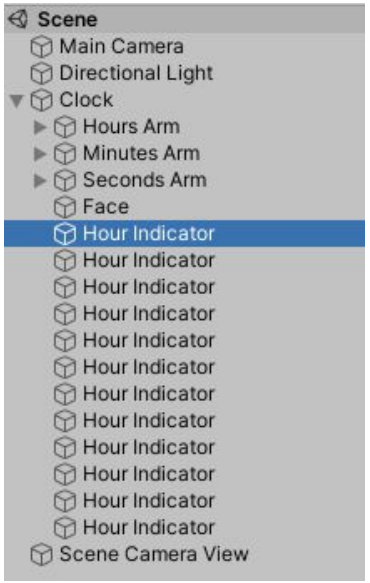
World (independent) TRS of the laptop

= World TRS of the desk * Local (considering the desk) TRS of the laptop

Hierarchy

World TRS of selected Hour Indicator

= World TRS of Clock * Local TRS of the Hour Indicator



Hierarchy

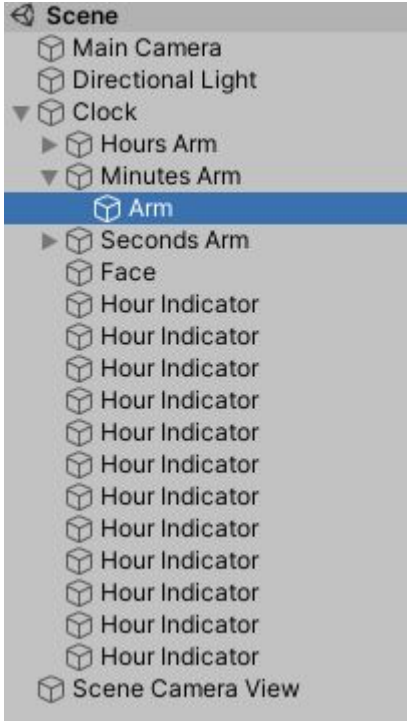
World TRS of selected Arm

= World TRS of Clock

* Local TRS of Minutes Arm

* Local TRS of selected Arm

At the end, the whole scene equivalent to a single object!



Computer Graphics

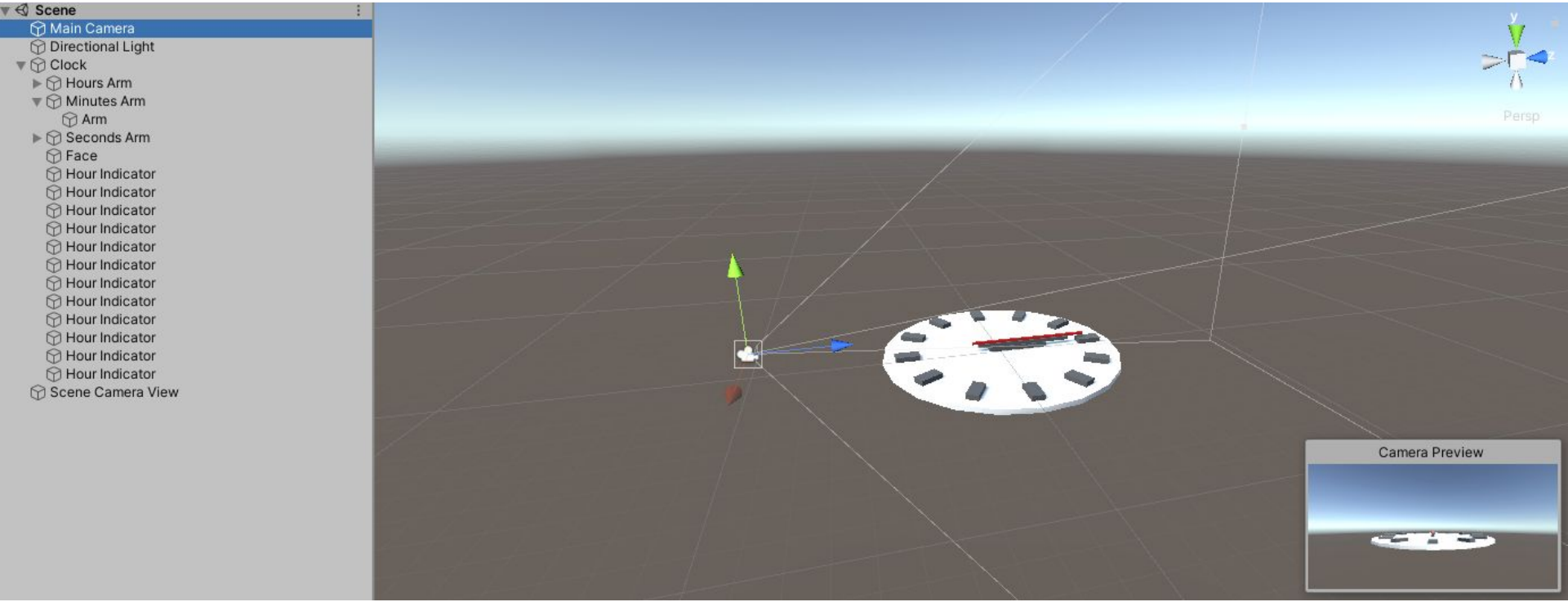
The case of our interest:

Converting a scene with virtual objects with a TRS of their own and a hierarchy between them into pixels of a screen.

A device that converts the real world to a projection?

Camera!

Camera in a 3D Scene



Real World Camera Example

Converting Scene to Pixels

A photograph depends on

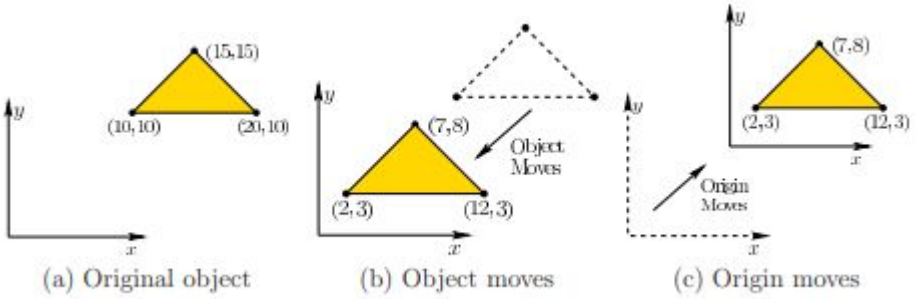
1. Where the subjects are
2. Where the camera is
3. What the settings of the camera are

Pixels from a scene depends on

1. Model matrix: another name given to the world TRS matrices
2. View matrix: the inverse of the world TRS matrix of the camera
3. Projection matrix: the settings written as a matrix

View Matrix

Inverse of a combination of translation, rotation, and scaling is still another combination of translation, rotation, and scaling.



(a) Original object (b) Object moves (c) Origin moves

Shader

How does a combination of mesh + texture + light turn into color?

Shader:

A program written for GPUs to compute pixels from the combination of meshes, textures, lights, and matrices.

Computer Graphics

Initial version of the case of our interest:

Converting a virtual world with virtual objects into pixels of a screen.

Current version of the case of our interest:

A scene with a camera inside it becomes pixels by shaders. Shaders convert the combination of meshes, textures, lights, and matrices that the scene contains.

Multiple Scenes for AR

In a typical computer game, there is only one scene, but for AR…

New thing to figure out:

The TRS matrices between scenes, and the real world.

Camera (or View Matrix) for AR

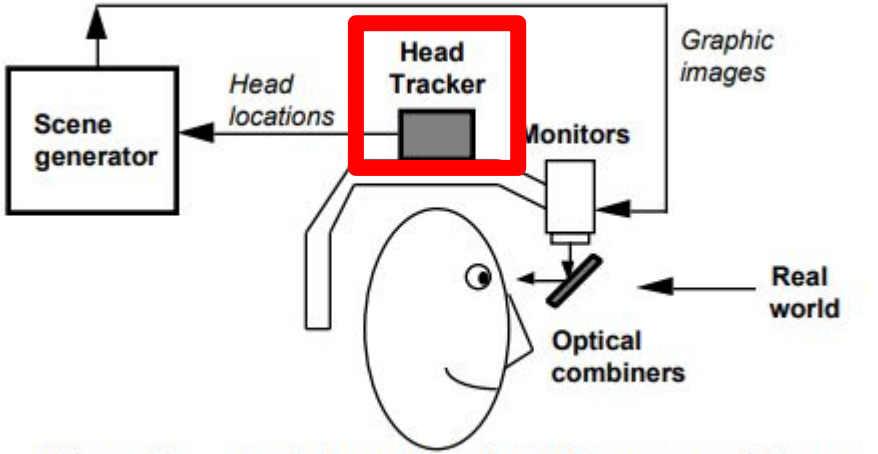


Figure 11: Optical see-through HMD conceptual diagram