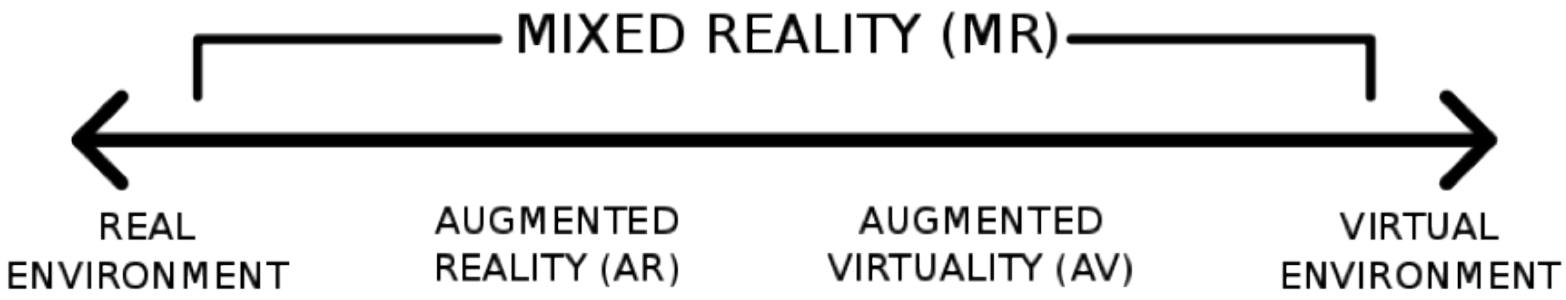
Marco Cavallo

Riverwalk: Incorporating Historical Photographs in Public Outdoor Augmented Reality Experiences

First of all…

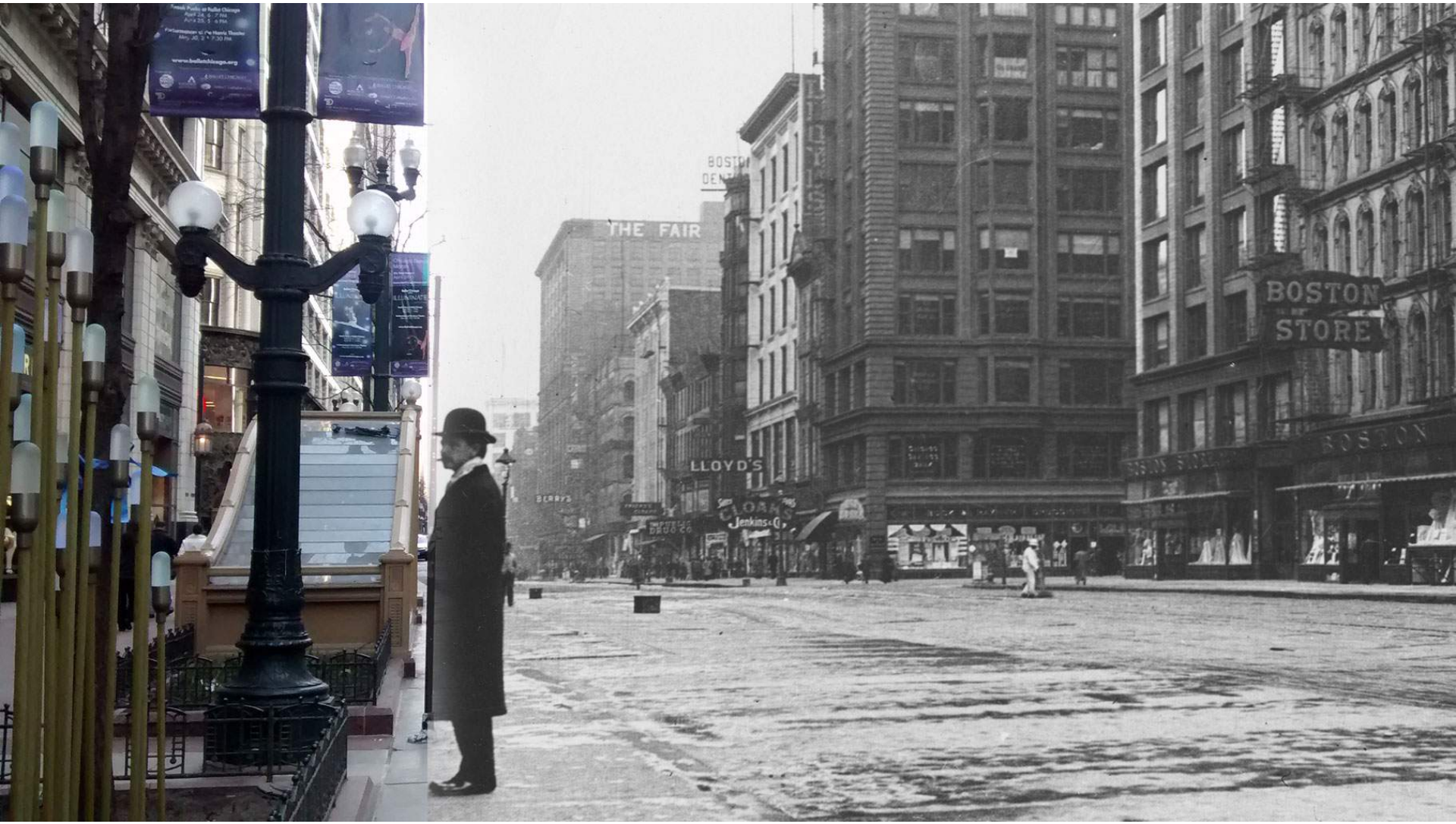


… some discussions about terminology used could be done, but for now we will stick to the term «**Augmented Reality**»

(Milgram, 1994)

Before…

…after



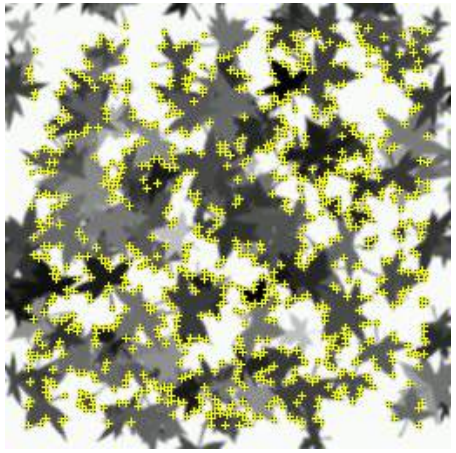
The Chicago 0,0 Project

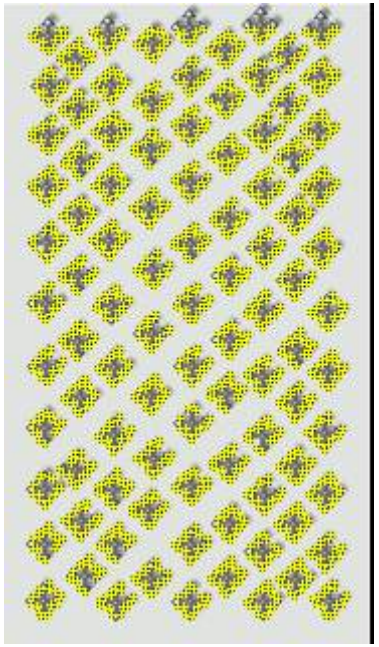
The Chicago 0,0 Project

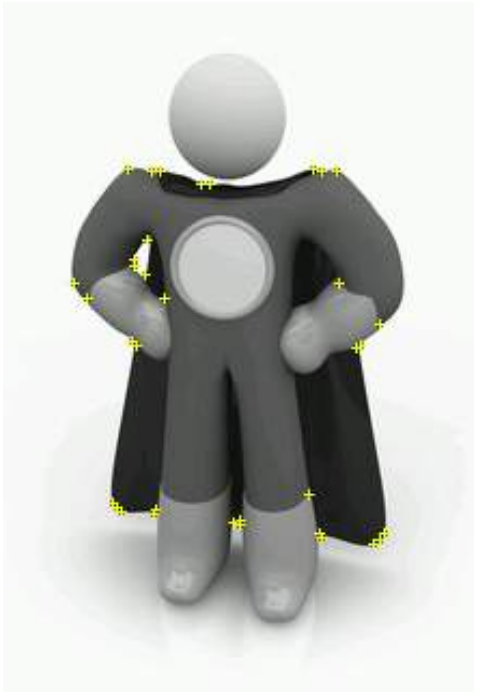
- Ongoing project
  >> in collaboration with **Geoffrey Alan Rhodes**
- **Chicago History Museum**'s massive photo archive

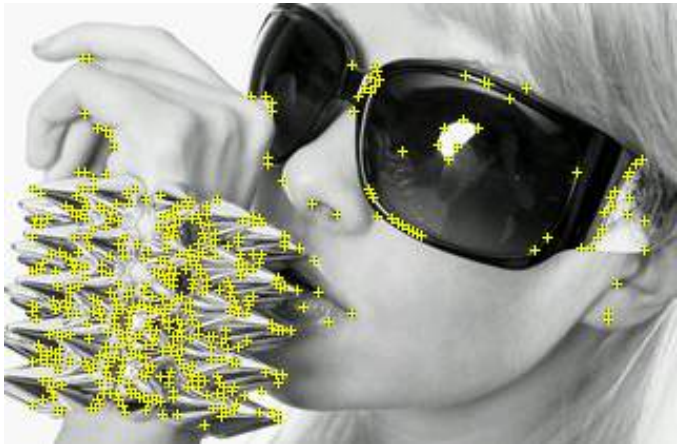
The limits of markerless AR

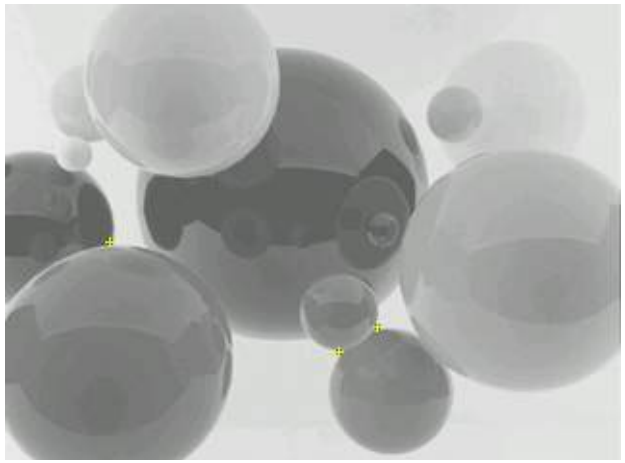
- Flat images
- Highly textured
- Feature distribution
- Avoid organic shapes
- Avoid repetitive patterns
- Good local contrast











Guess what?

- Repetitive patterns (windows!)
- Sometimes uniform in color
- Lighting and weather conditions
- Flat…?

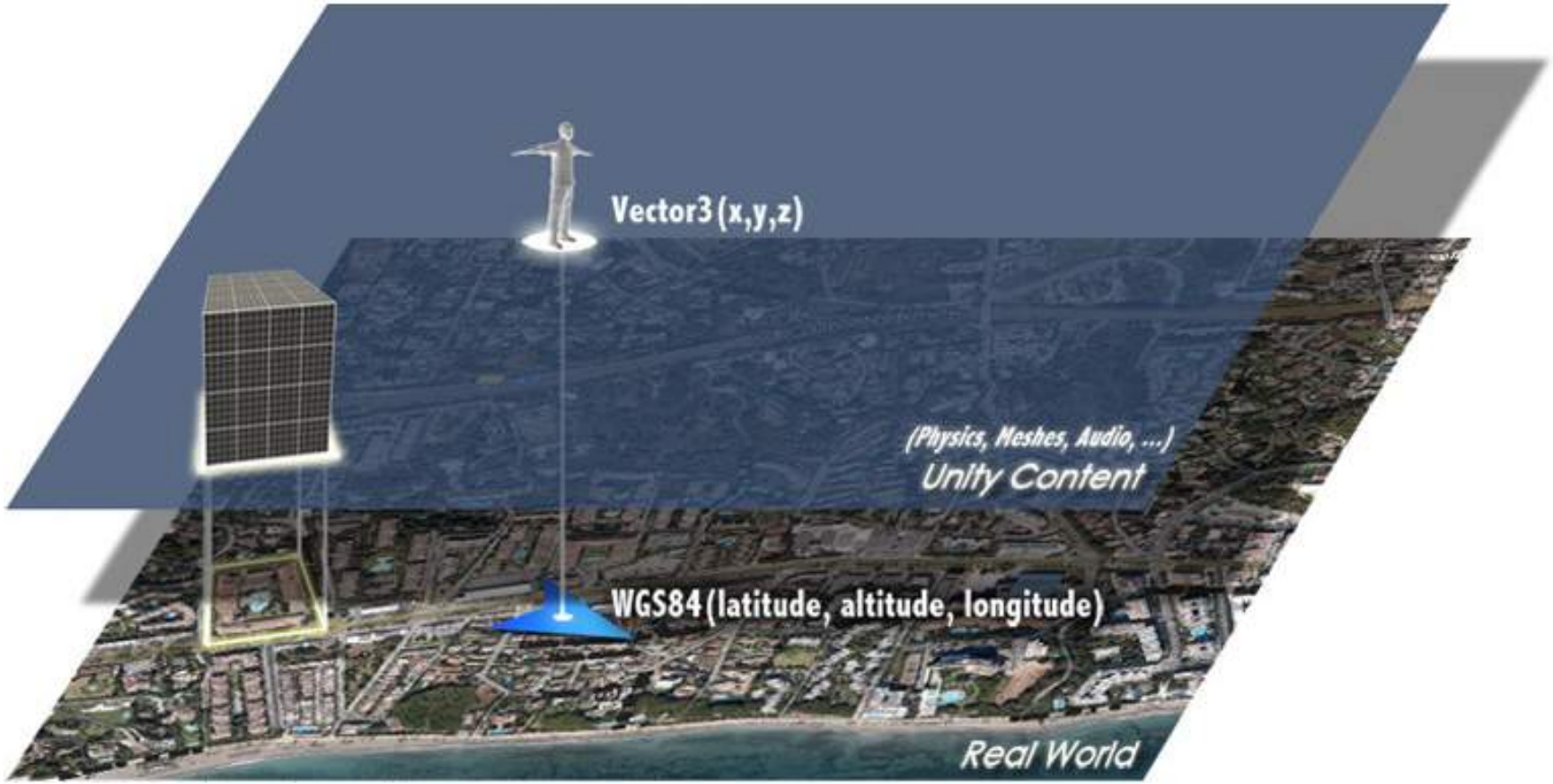
Additional complaints

What if…

- No features to be tracked?
- No flat images to track?
- We wanted to create more complex behaviors?
- We wanted to improve the design process?

Our solution: geolocating content

Towards an absolute camera pose

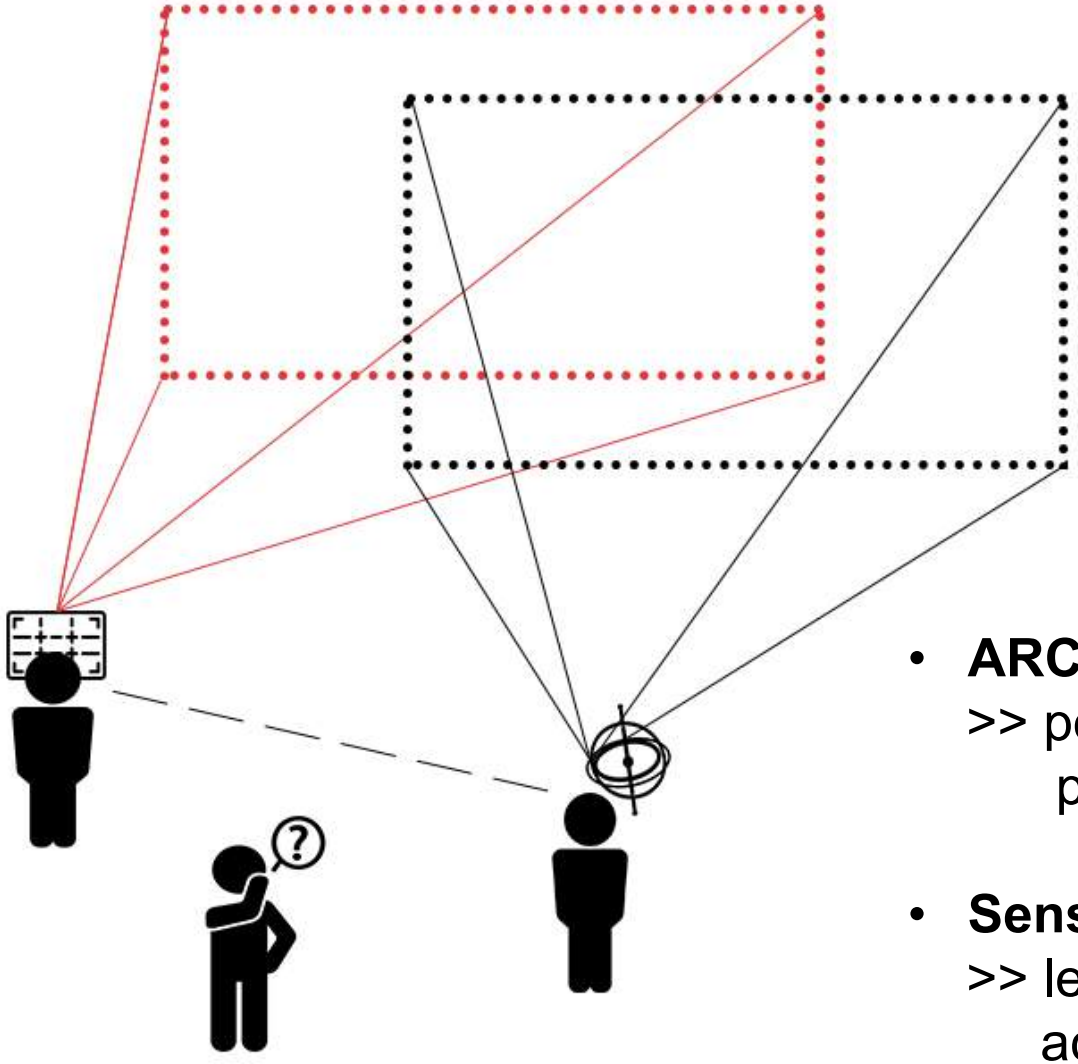


Both overlays and fiducials are geolocated!

… we live in a 3D world after all :)

The dual camera approach

… an abstraction for
Markerless & Location-based AR

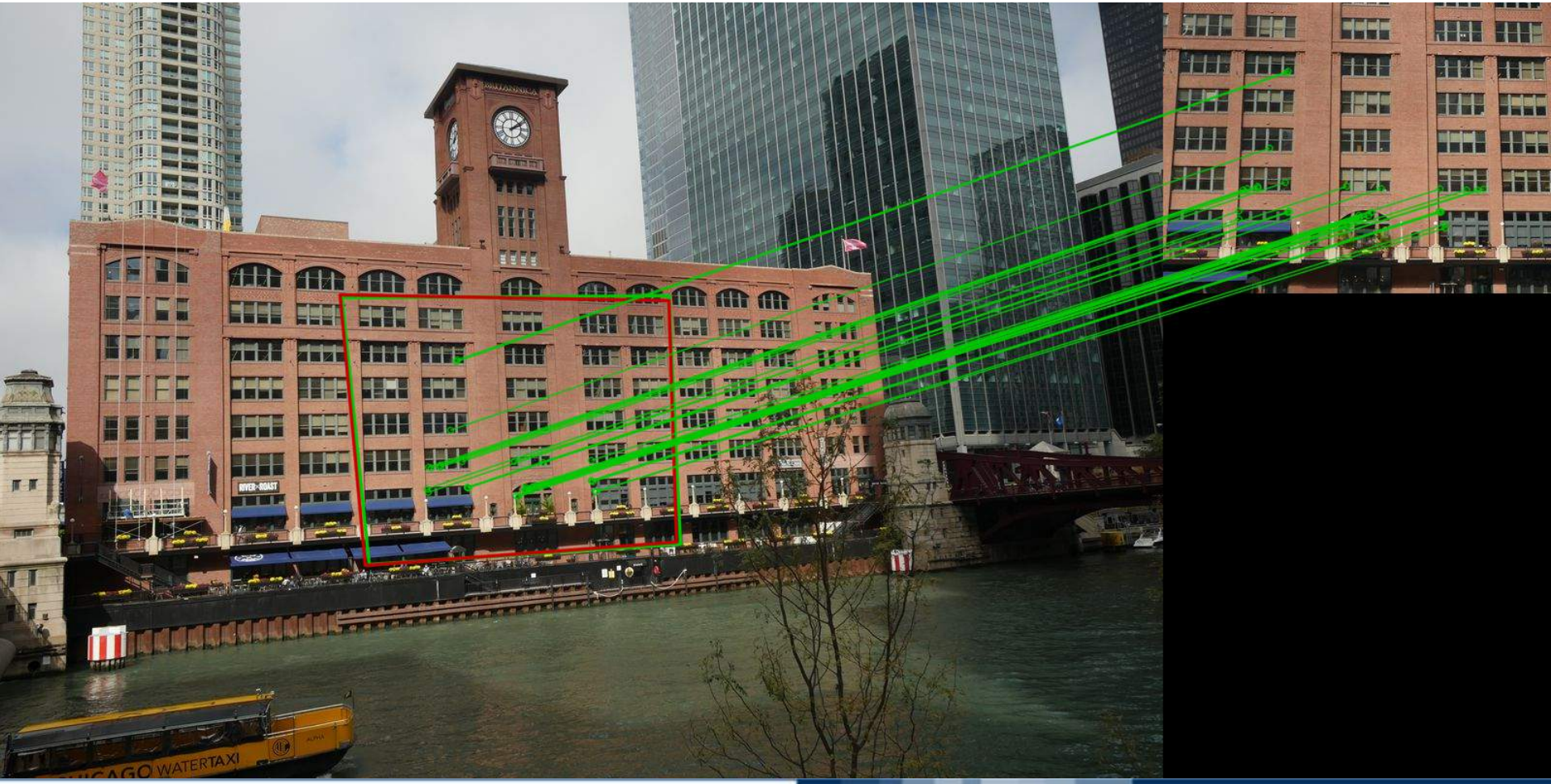


- **ARCamera**
  >> pose estimated through pattern-based image tracking
- **SensorCamera**
  >> leveraging geomagnetic field, accelerometer and gyroscope

The ARCamera

- Temporary solution -> general purpose markerless AR and… oversampling :-/
- Future solution -> specific algorithm for architectural features

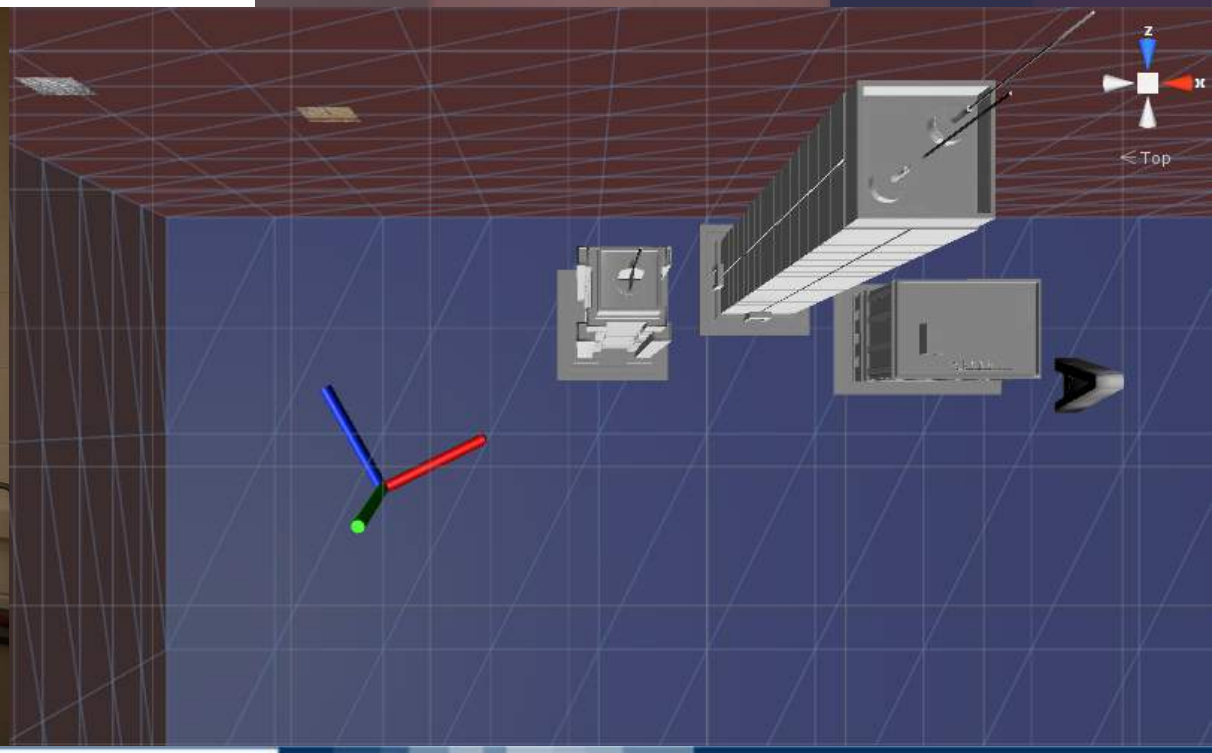
… approach by itself algorithm-independent



The ARCamera

But… what's the novelty?

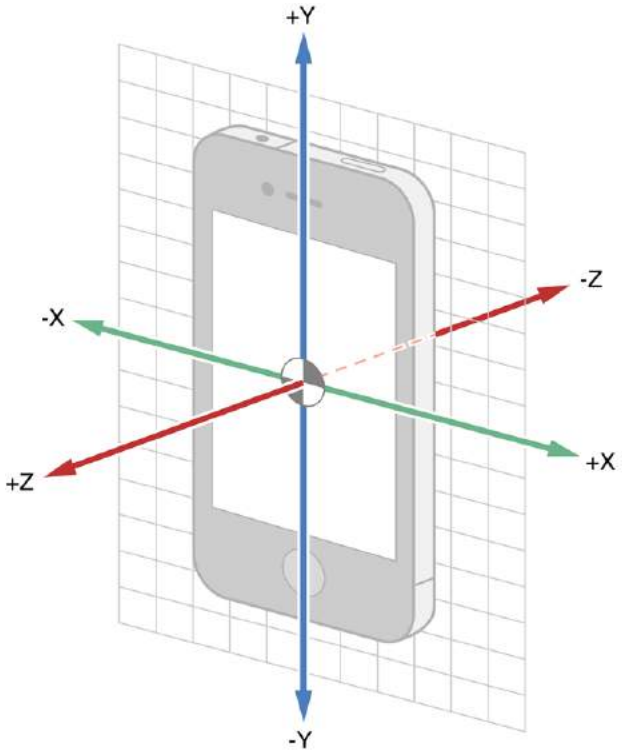
Absolute positioning!!

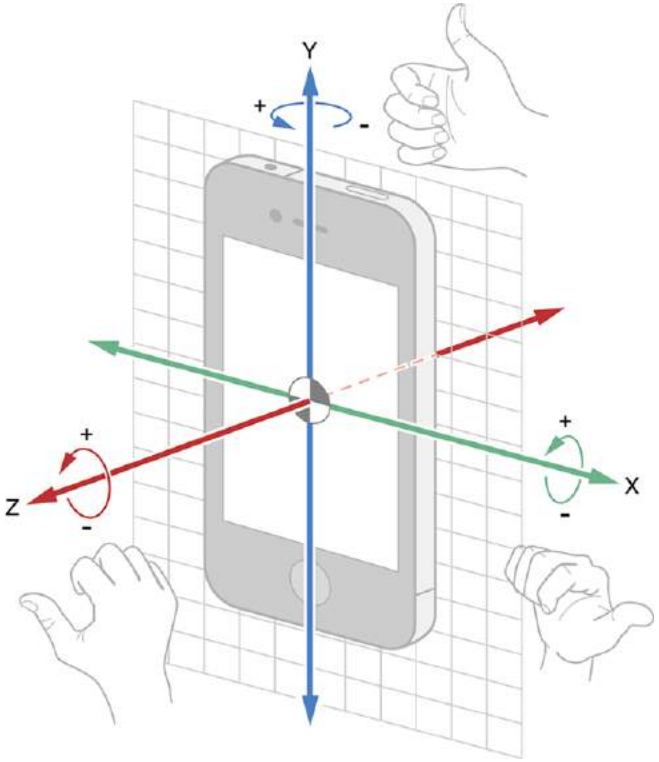


The SensorCamera

- Absolute position: (A-)GPS
  >> Corrected with step detectors, multi-sensors odometry, visual odometry

- Absolute orientation: Inertial Measurement Unit (IMU)
  >> Accelerometer, Gyroscope, Magnetic field





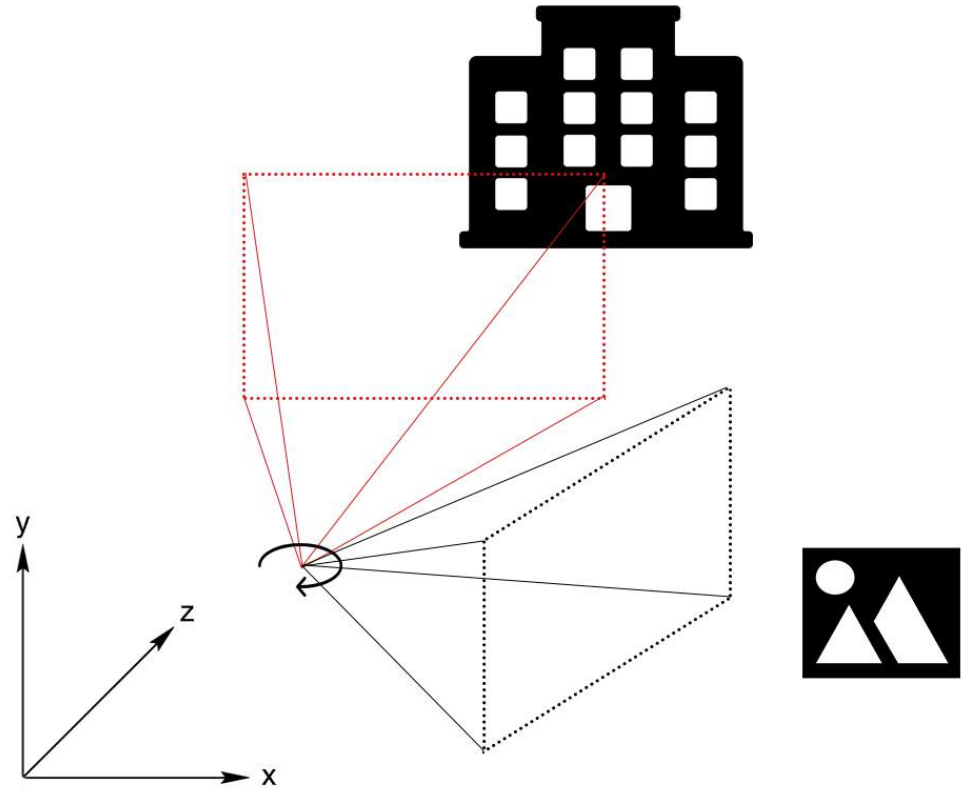
Estimating the pose of the camera

$$\triangle r = r_{ar}^{-1} * r_s$$

$$r = r_s * \triangle r$$

$$pos_{smoothed} = pos_{old} + (pos_{current} - pos_{old}) * \frac{k_1}{dist} * time_{frame}$$

$$rot_{smoothed} = rot_{old}(rot_{old}^{-1} * rot_{current})^{\frac{k_2}{dist} * time_{frame}}$$



4 cases to be handled:

- Fiducial found
- Fiducial lost
- Multiple fiducials
- No fiducials available

General advantages

- Absolute Geolocation

  >> Abstract location-based and marker-less AR as a single experience

  >> Load and unload content based on user location

  >> Display **virtual content even if no tracking is available**

  >> Know **virtual content close to user** or to other virtual content

  >> **Prune the dataset** of pattern images based on proximity

  >> Virtual environment where to **edit and preview the application**

  >> **Dynamic resource management**

General advantages

- Absolute orientation:

  >> Know how much user is **moving away from a tracked object**

  >> Display **objects even if tracking has been lost**

  >> **Know how to orient user** towards other virtual content

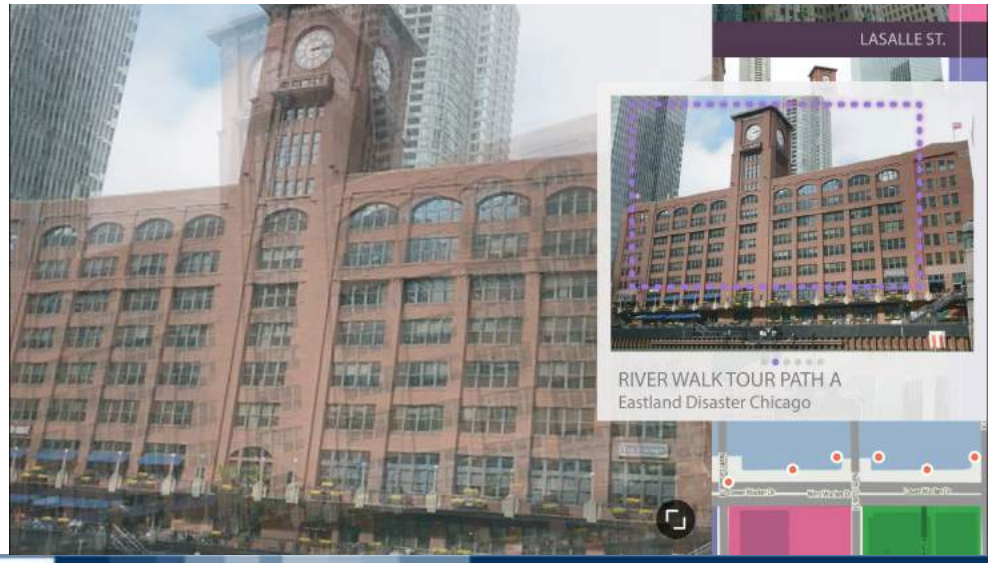
  >> Know how to **filter virtual content if overlapping**

  >> Signaling **incoherent situations** and false positives / negatives

  >> **Intelligent camera smoothing** (stabilization)

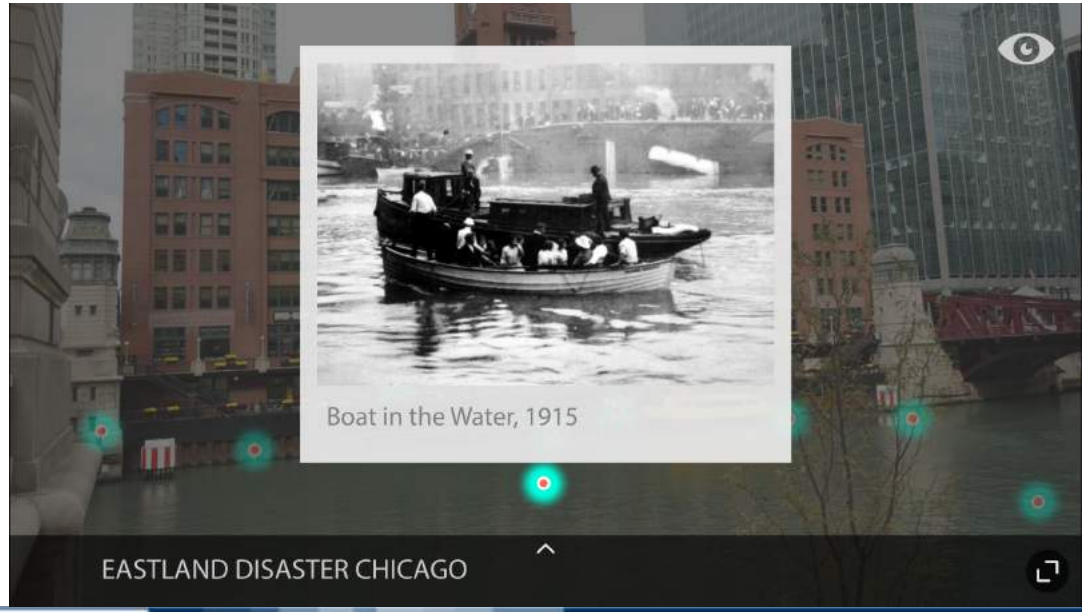
Navigation & information browsing

- **Color coding** and showing available content
- **Showing target** where the user has to aim
- Indicating whete to move / rotate to **next object**
- Indicate when device needs **calibration**
- Allow **transitions** between adjacent / overlapping content
- Suggest the user where to position to **see from a particular perspective**
- **Map** + optional navigation
- Allow user to move / modify / **correct by himself**?



Just to be sure…

- Weather conditions
- Absence of light
- Device limitations

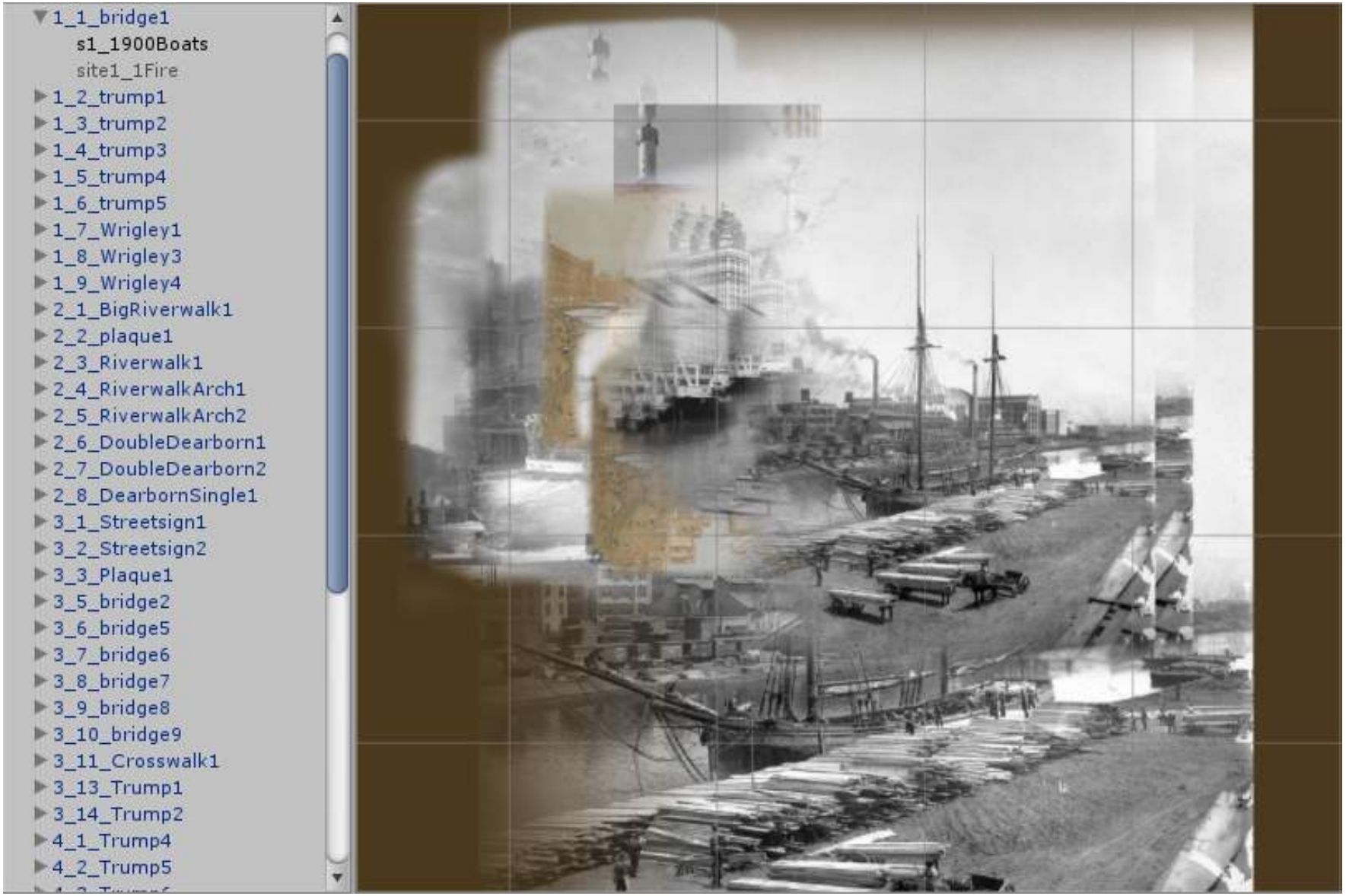


… always keep a classic user interface to allow users visualizing the content

The designer perspective

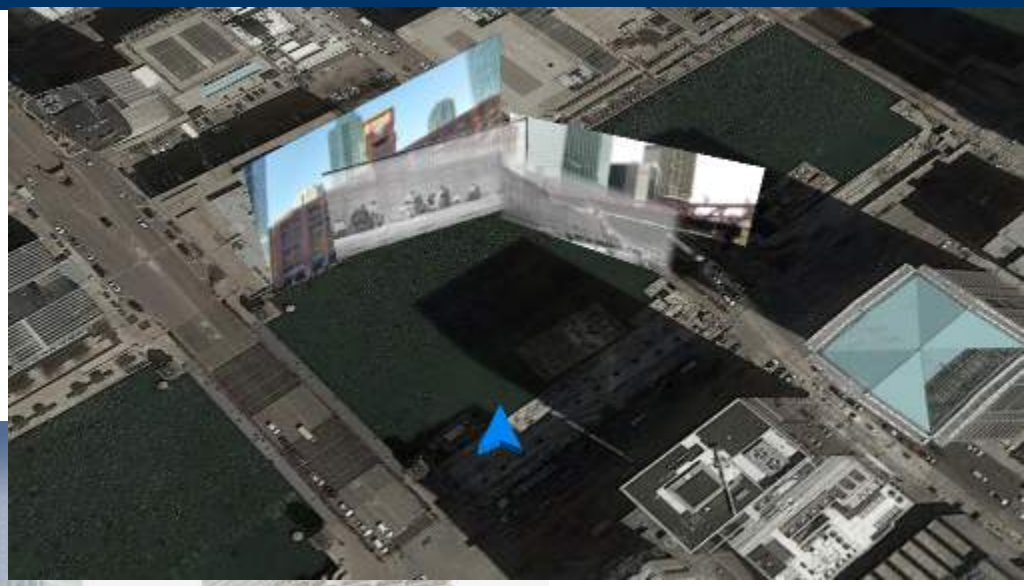
… ever wondered?

The designer perspective



Towards a first authoring tool

- Selecting view points
- Placing overlays
- Previewing them offline…



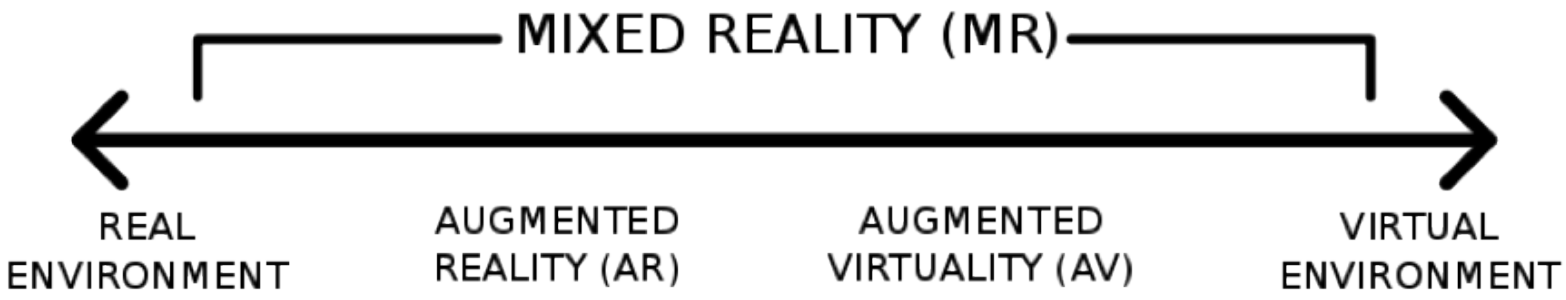
…simulating the user's experience!!

What's next?

Ops… now we'll go a bit off-topic :)

… or maybe not?

Not that again!



Let's broaden our term… let's use <<**Mixed Reality**>>

(Milgram, 1994)

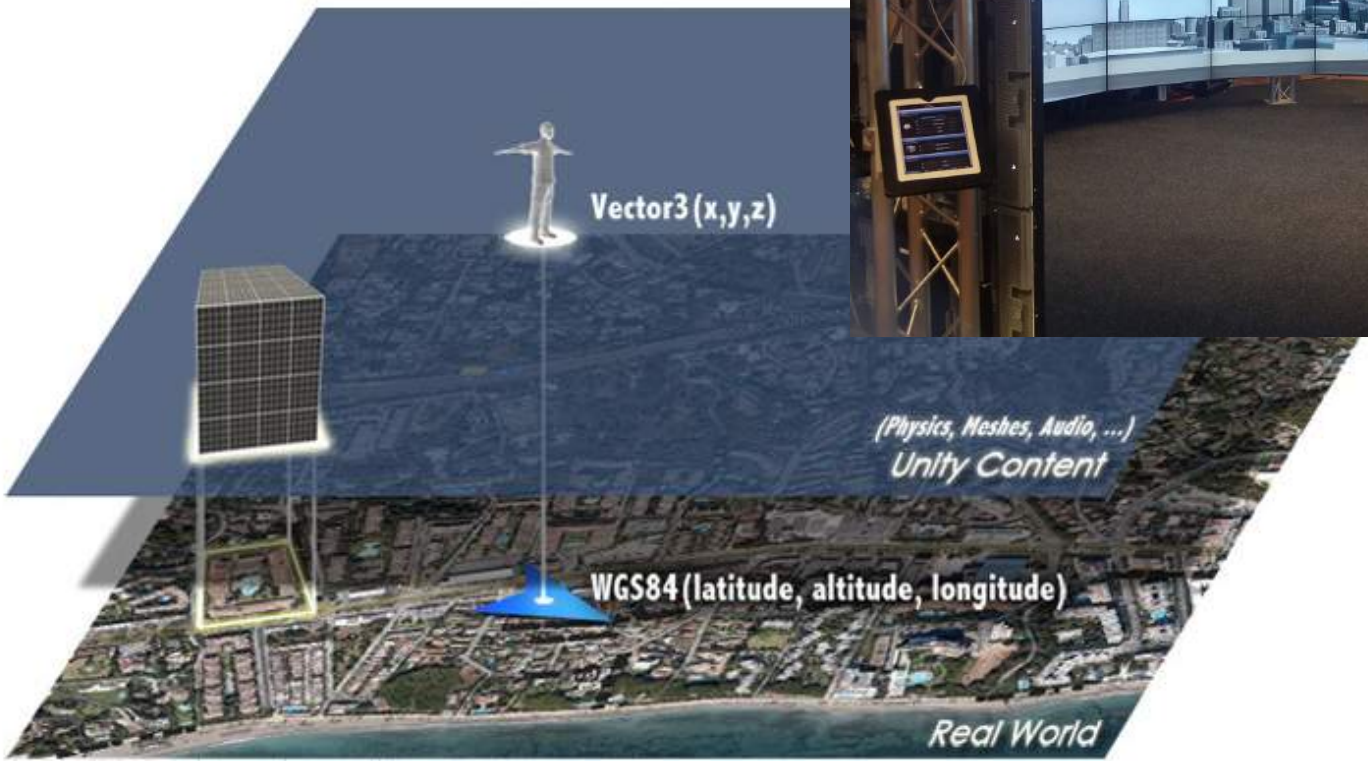
Let's think outside the box

What if we could…

- Create a better way to **design and edit** MR experiences
- Modify at **runtime** the MR experience
- Study **how users behave** while using our application
- **Interact selectively** with them

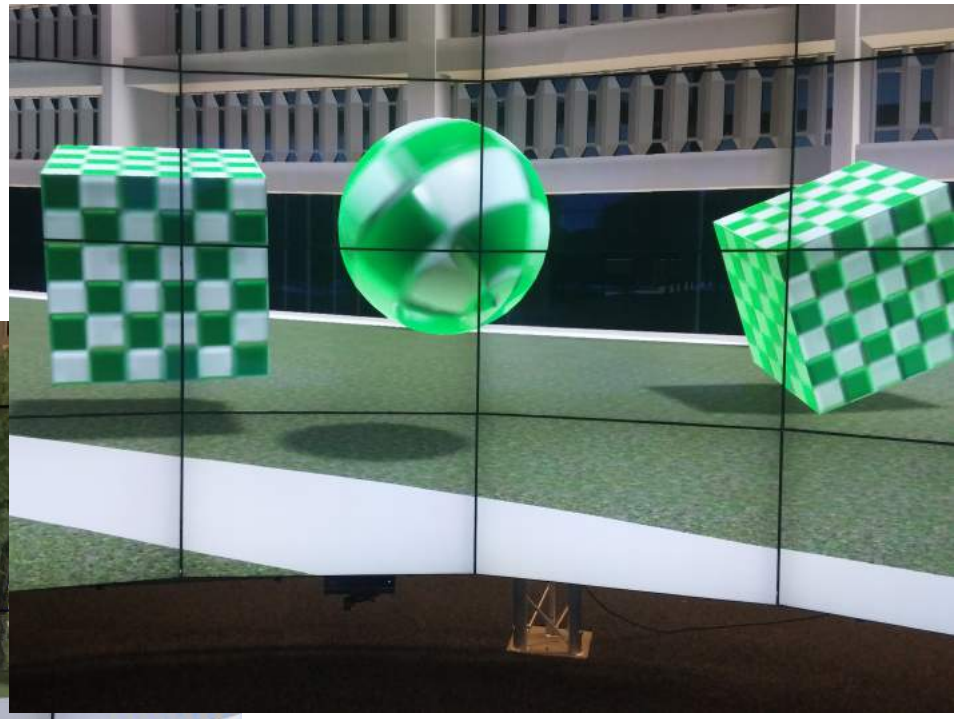
Merging the two worlds

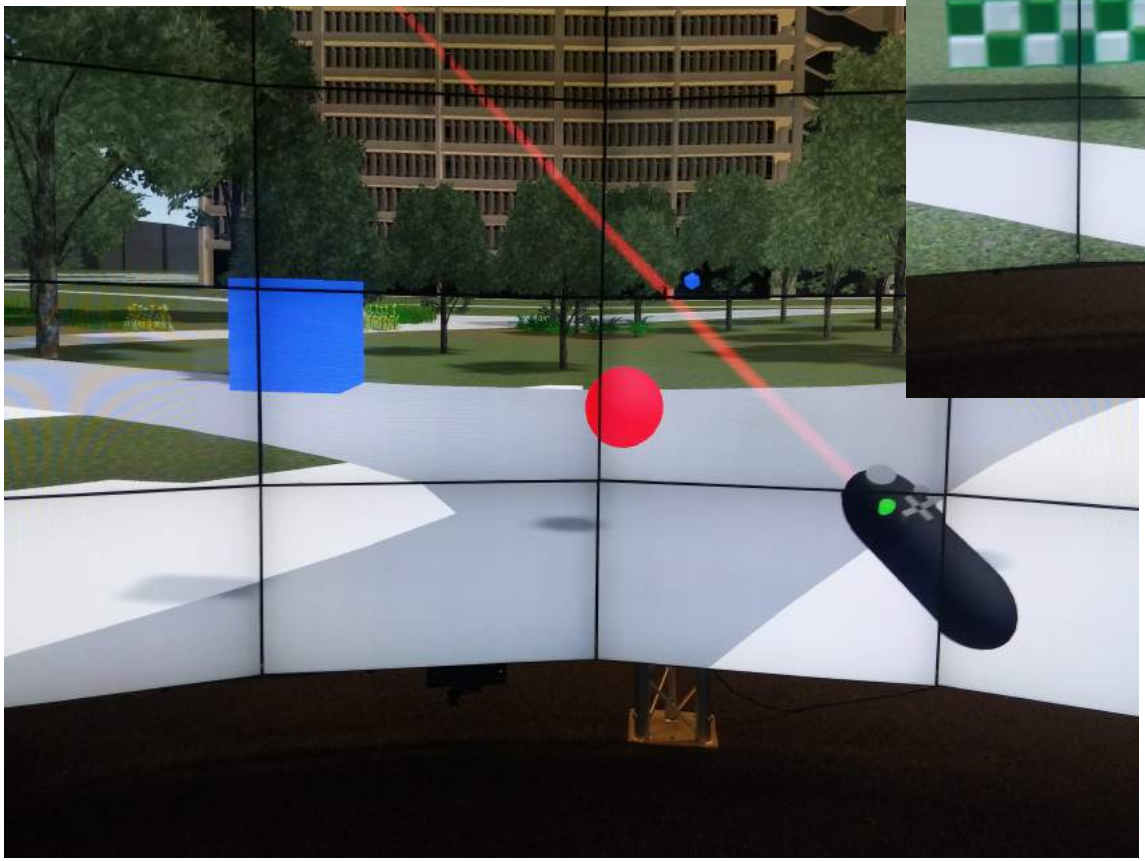
1:1 mapping to real-world locations



An editor but also…

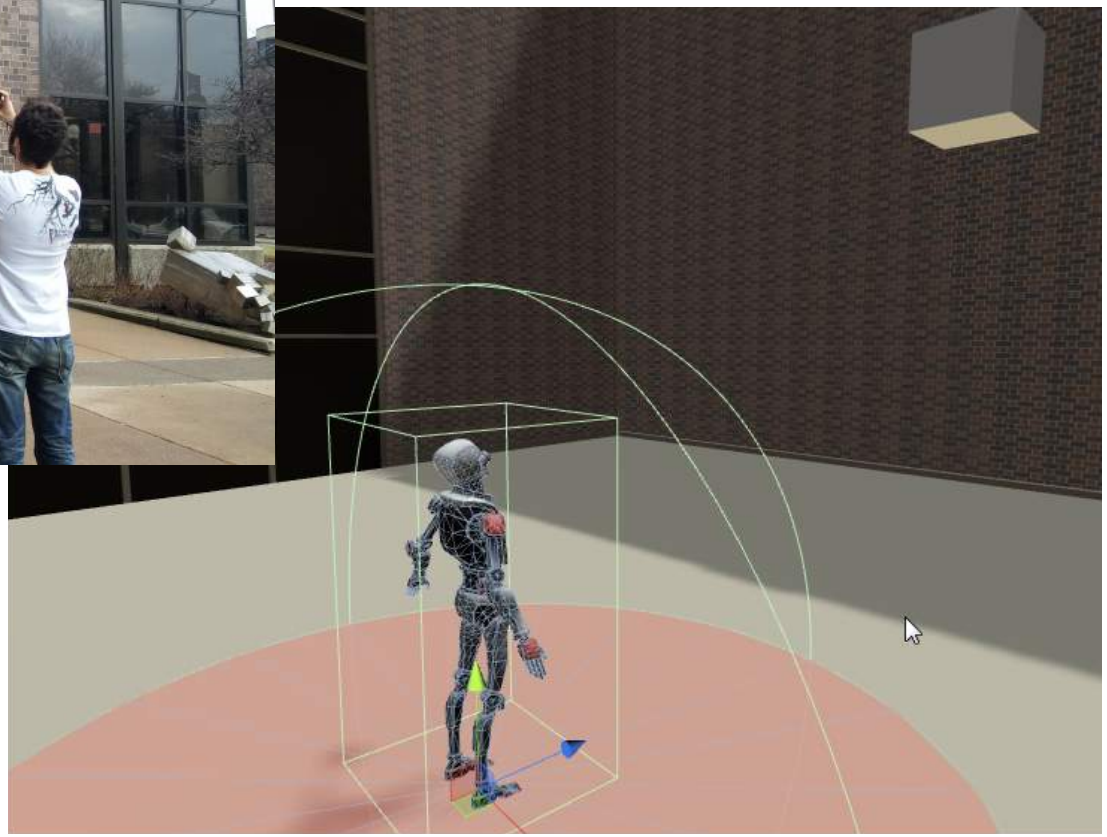
Not only a nice way to edit virtual content





A portal between realities

Content modified **real-time** on clients



Users represented **as avatars with 4+3 DOF**

Many new possibilities!!

- **Real-time content customization** in order to solve problems or satisfy user needs
- Possibily to analyze the **behavior of users** and to store significant data
- Possibility to **interact with users in MR**
  >> Create private audio and video channels
  >> See from **their real-world perspective**
  >> **Debug** the whole MR solution
  >> **Add ourselves to their MR experience**

Thanks for watching ;)