Virtual Reality and Augmented Reality

AR Technology

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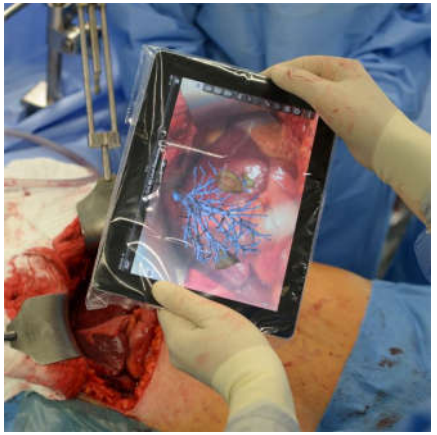
AR Requires Tracking and Registration

Registration

- Positioning virtual object **relative to** real world
  - Fixing virtual object on real object when **view is fixed**

Calibration

- Offline measurements
  - Aligns the camera position relative to the headset.

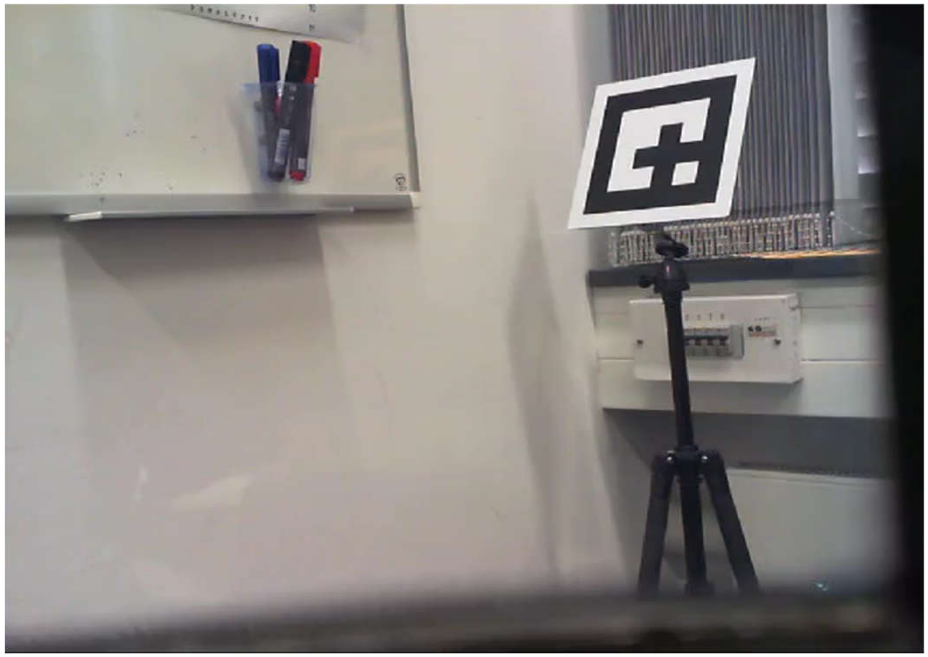


Tracking

- Continually locating the user's viewpoint when **view moving**
  - Position (x,y,z), Orientation (r,p,y) *[roll, pitch, yaw]*

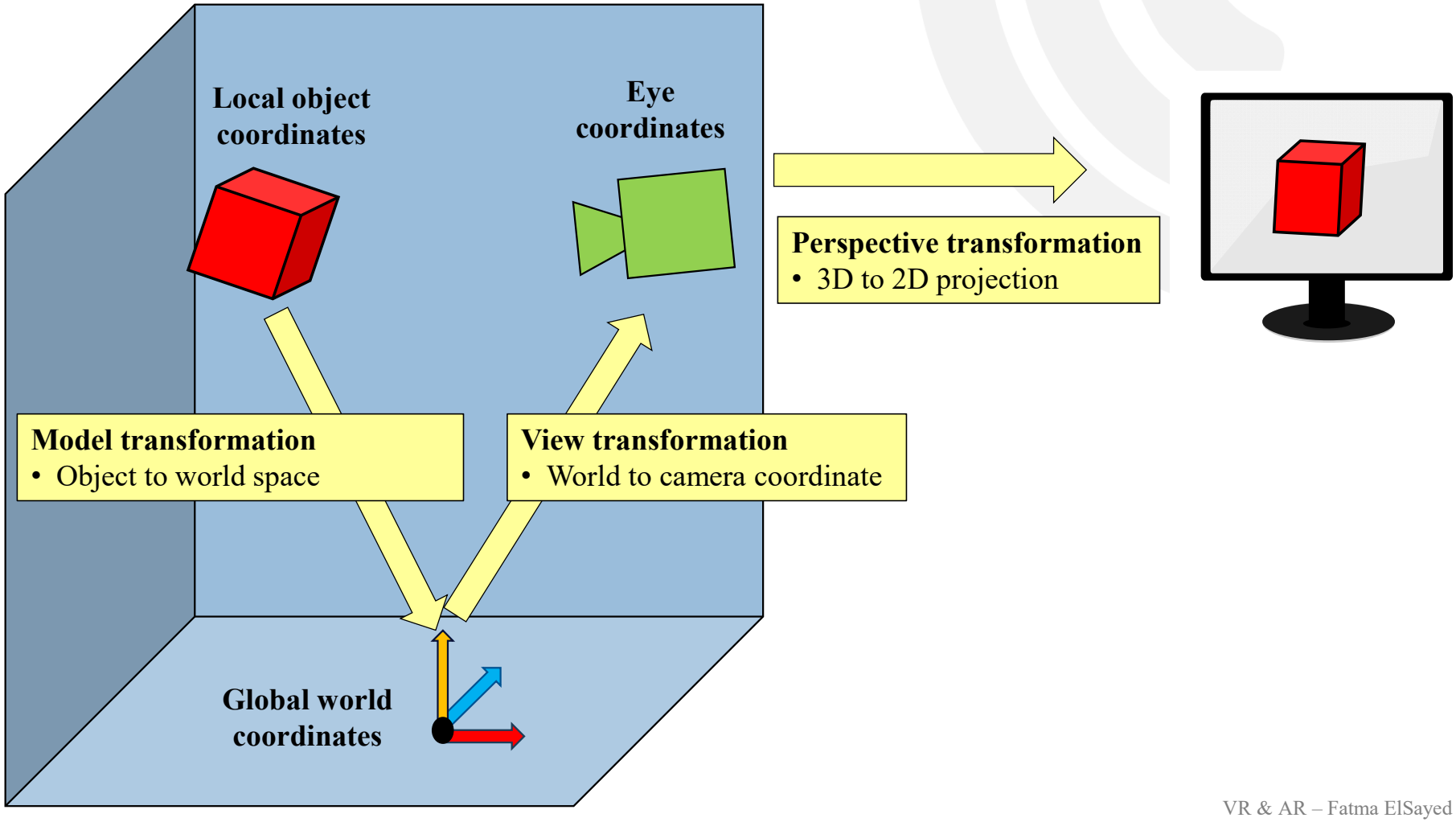
The Benefit of Calibration

Uncalibrated



Calibrated

Coordinate Systems



Coordinate Systems

Local Object Coordinates:

- Each object (e.g. car) has **its own** coordinate system.
- This is its local space, **independent of** the world around it.

For example: All parts of the car (wheels, doors, chassis) are positioned relative to the car's center (0,0,0).

Global World Coordinates:

- Objects are placed in a world coordinate system.

Model Transformation:

- Moves objects from **local object coordinates to global world** coordinates.

For example: If the AR system detects a table, it automatically places the car in a suitable position.

Coordinate Systems

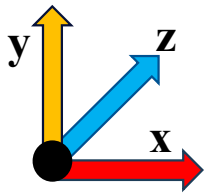
View Transformation:

- Converts coordinates **from world space to eye coordinates** *(camera view).*
- If the observer (camera) moves, all objects transform accordingly.

Example: If the user moves closer, the car appears larger; if they walk around, they see different angles.

Perspective Transformation:

- Converts **3D eye coordinates into a 2D screen** projection.
- Farther objects appear smaller, and closer objects appear larger, creating **depth perception.**



x → Left/Right (horizontal movement)
y → Up/Down (vertical movement)
z → Forward/Backward (depth movement)

Tracking

Tracking Requirements

- Tracking requirements in AR **increases** based on stabilization levels.

Augmented Reality Information Display

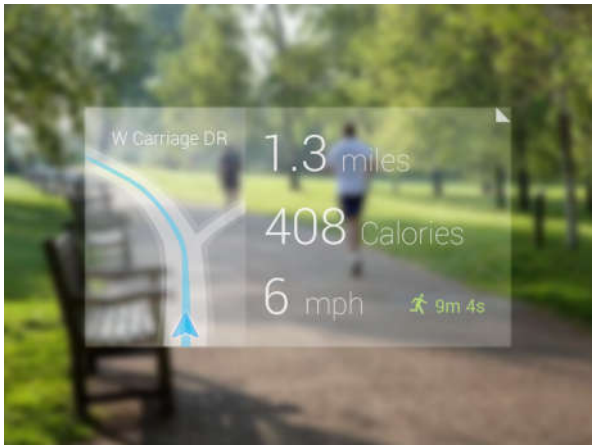
1. **World-stabilized**
2. **Body-stabilized**
3. **Head-stabilized**

Increasing Tracking Requirements

Tracking Requirements

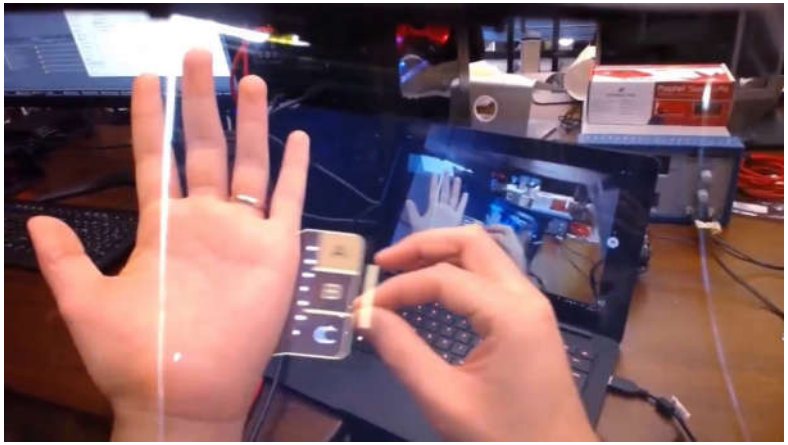
1. **Head-stabilized**
   - The virtual content is **attached to your head**
   - The information is always in **front of the eyes** *(information always visible)*
   - Requires **minimal** tracking *(just tracks head movements).*

   For example: Google glass



Tracking Requirements

2. Body-stabilized

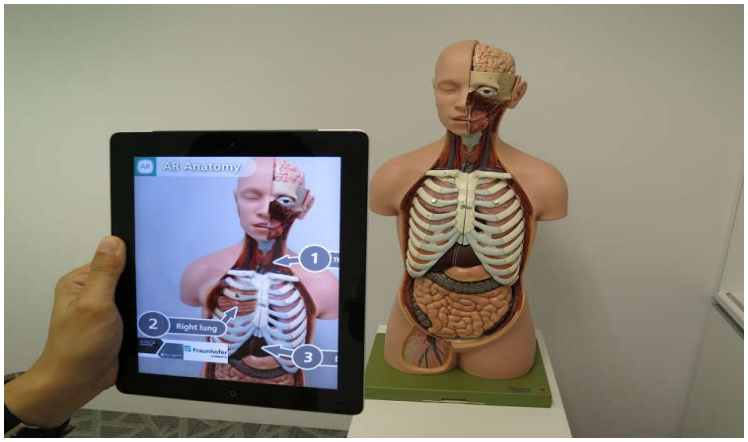


- The virtual content **moves with your body**.
- Is always available **but not always visible**, meaning it can appear when needed.
- The system must track both head and body positions.

For example: AR Smartwatch Interface – Virtual controls appear when you raise your hand.

Tracking Requirements

3. World-stabilized



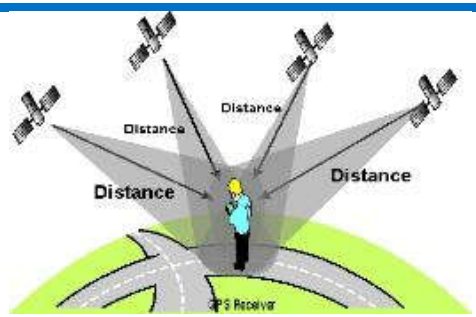
- Virtual objects stay **fixed relative to the real world**, even when you move your head or body.
- The system must track the environment and update the object's position correctly.

For example: Navigation AR app

Tracking Technologies

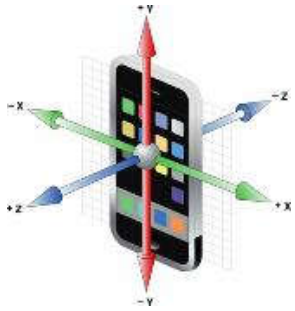
Active

- Uses external signals to determine position.
- GPS, Wifi, cell location



Passive

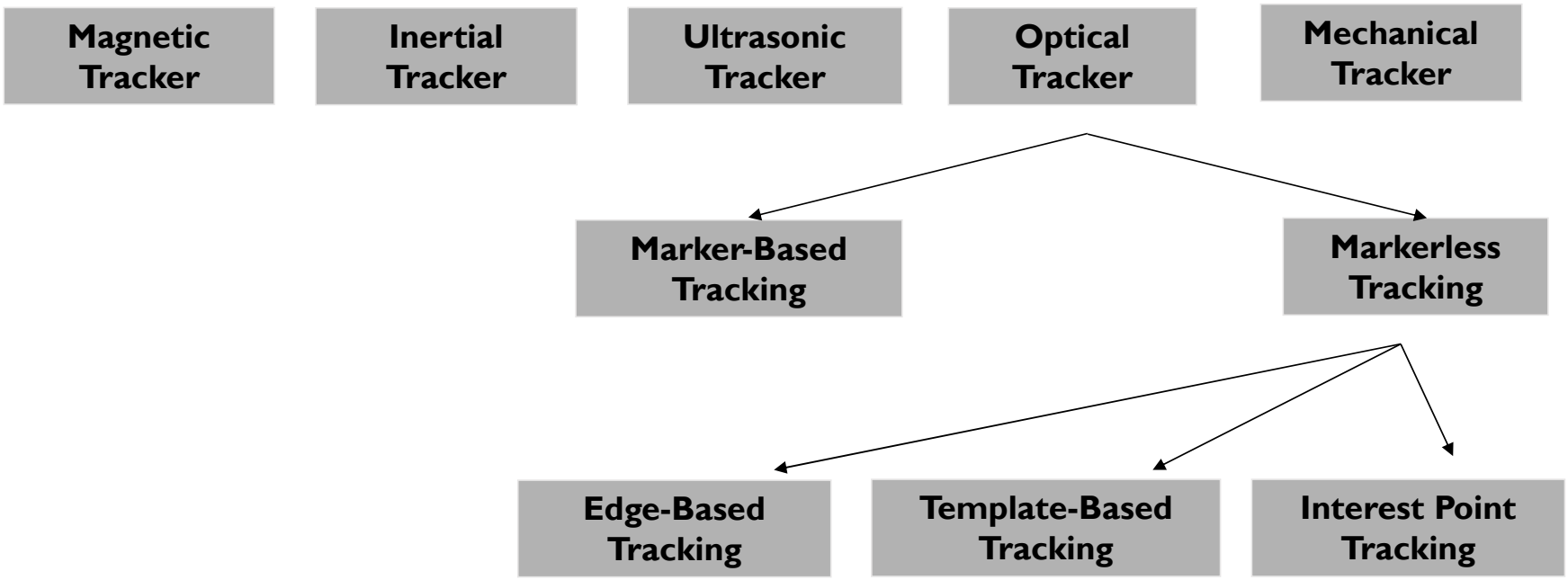
- Inertial sensors (compass, gyroscopes)
- Computer Vision



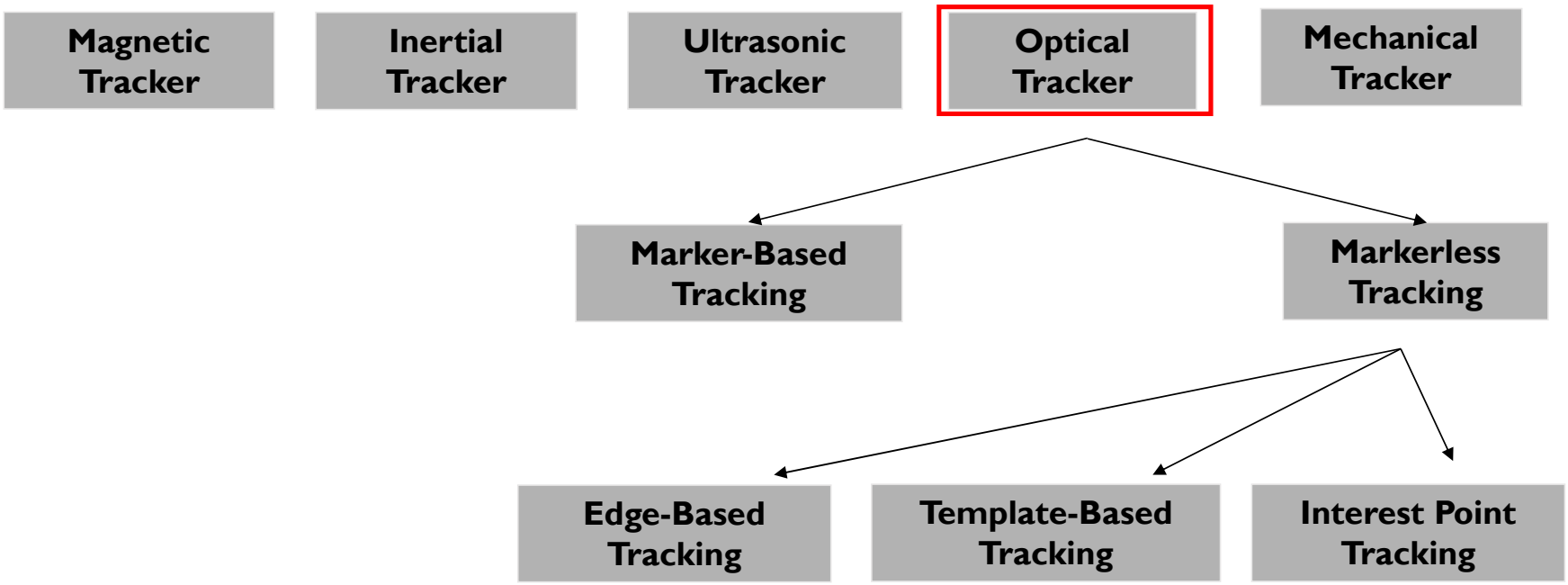
Hybrid Tracking

- Combined sensors (eg Vision + Inertial)

Tracking Types



Tracking Types



Why Optical Tracking for AR?

Optical Tracking is a method that uses **cameras and image-processing algorithms** to track objects in real-world environments.

- **Many AR devices have cameras**
  - Mobile phone/tablet, Optical/Video see-through display
- **Provides accurate alignment between virtual / real objects**
  - Real world has many visual features that can be tracked from
- **Computer Vision well established discipline**
  - Over 40 years of research in computer vision has contributed to the development of robust tracking algorithms.

Common AR Optical Tracking Types

Marker-based Tracking

- Tracking known artificial markers or images
- The AR system recognizes these markers and overlays virtual objects on them.
- Works well in controlled environments with good lighting and visible markers.

e.g. QR codes, ARToolKit square markers

Common AR Optical Tracking Types

Markerless Tracking

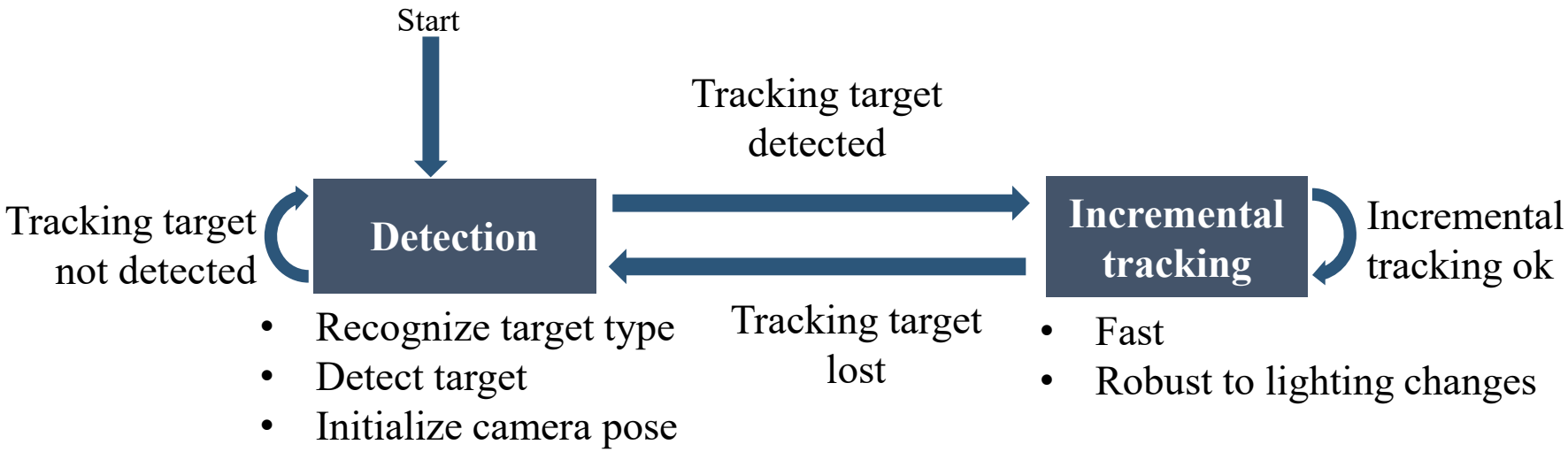
- Tracking from known features *(natural features)* such as edges, textures in real world
- Uses computer vision to recognize objects, images, or surfaces *(like walls, tables, or books).*

e.g. Vuforia image tracking

Demo: Vuforia Texture Tracking

https://www.youtube.com/watch?v=1Qf5Qew5zSU

Detection and Tracking



- Tracking and detection are complementary approaches.
- After successful detection, the target is tracked incrementally.
- If the target is lost, the detection is activated again

THANK YOU