

Computer Vision Challenges for Virtual Reality



Dov Katz

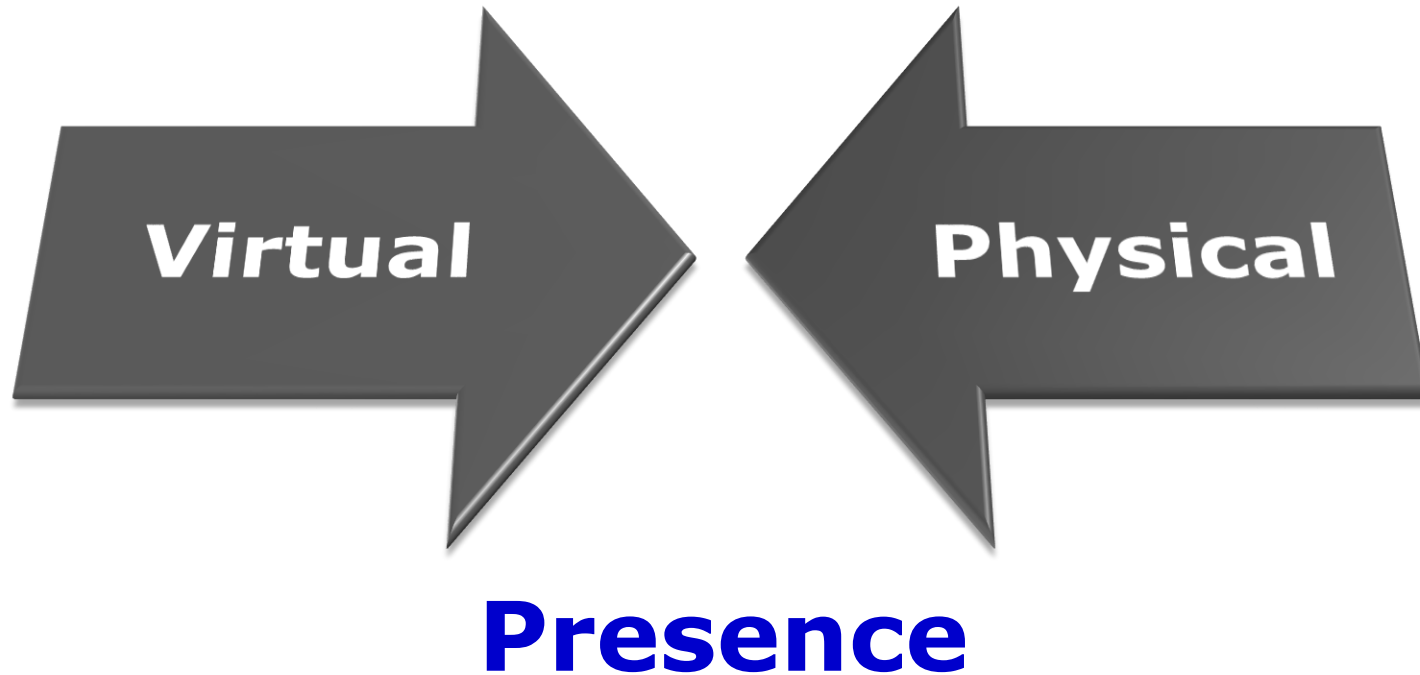
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The (*last*) Platform



Computer Vision?



Why Tracking?



No Tracking



3-DOF



6-DOF



Tracking Hardware: HMD

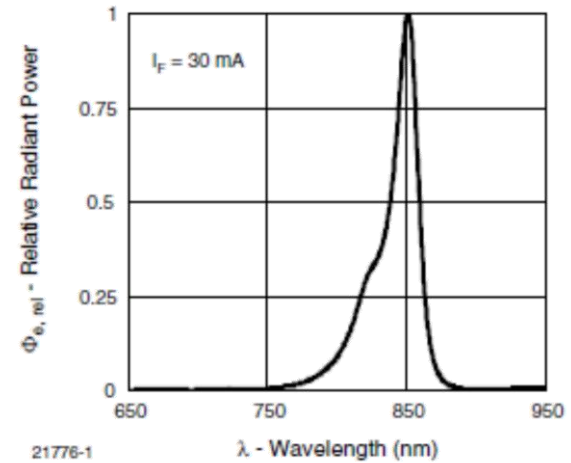
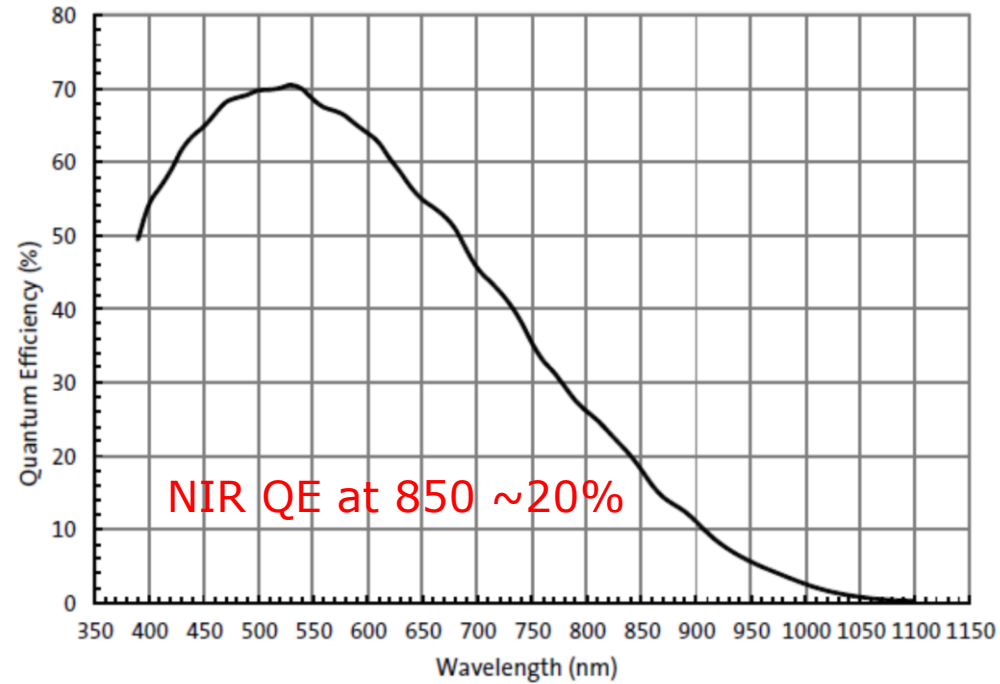


Fig. 5 - Relative Radiant Power vs. Wavelength



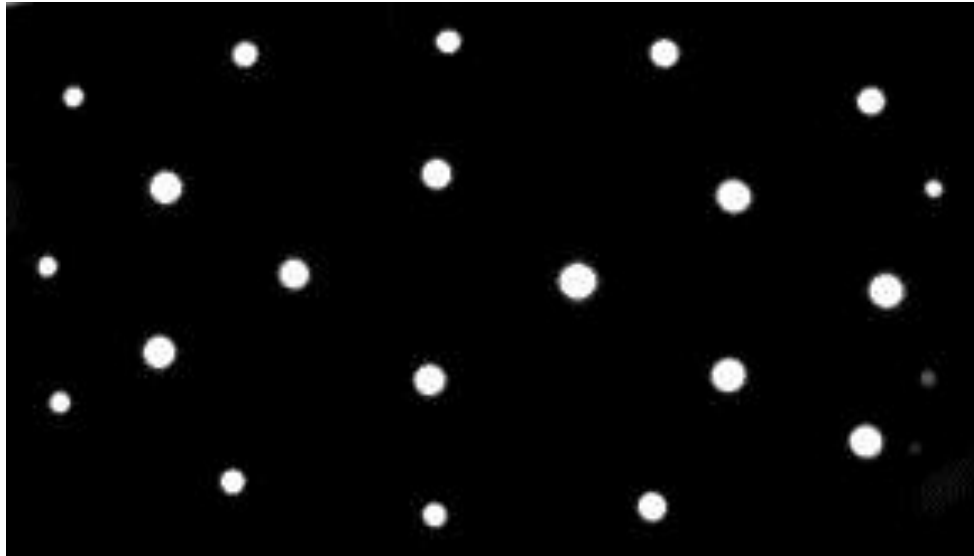
Peak wavelength: 850[nm]
Angle of half intensity: $\pm 60^\circ$

Tracking Hardware: Camera



- Global shutter
- IR filter
- Exposure time $\sim 200[\mu\text{s}]$
- Wireless sync shutter \leftrightarrow LEDs

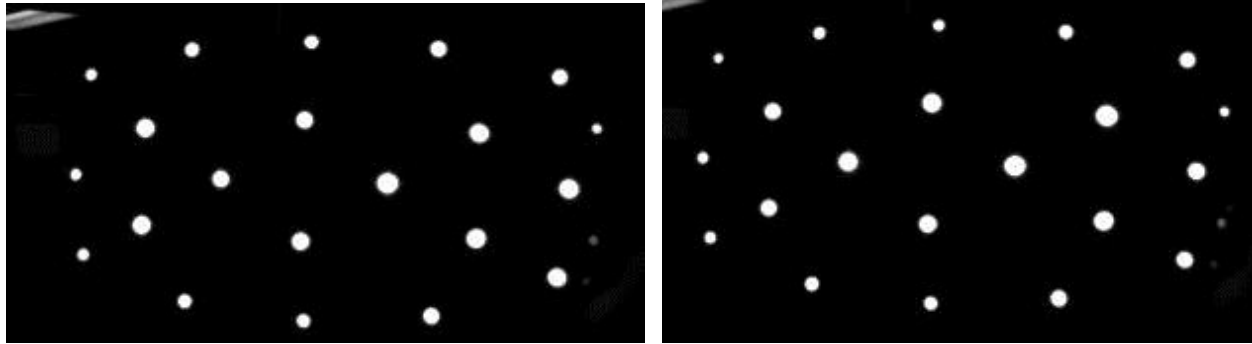
Vision Pipeline: Blob Segmentation



- Centroid
- Size
- Brightness
- Shape

Distortion Correction

Vision Pipeline: Decoding w\ Modulation



High

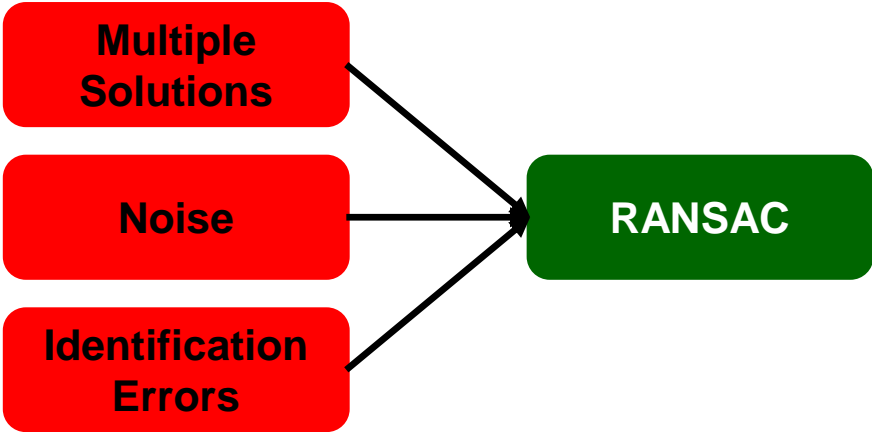
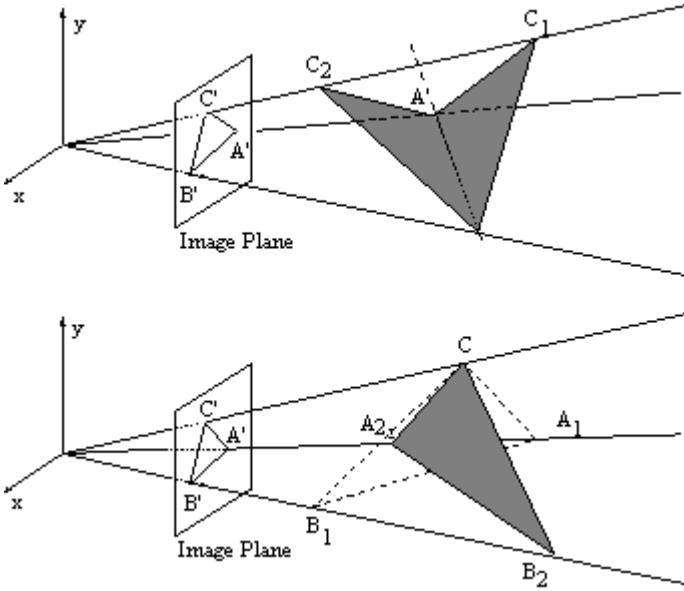
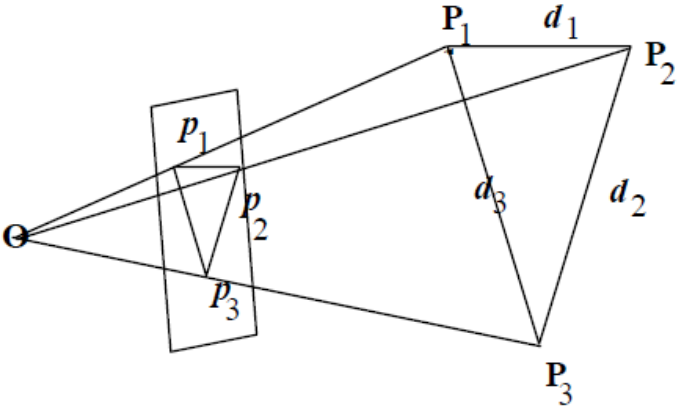


Low

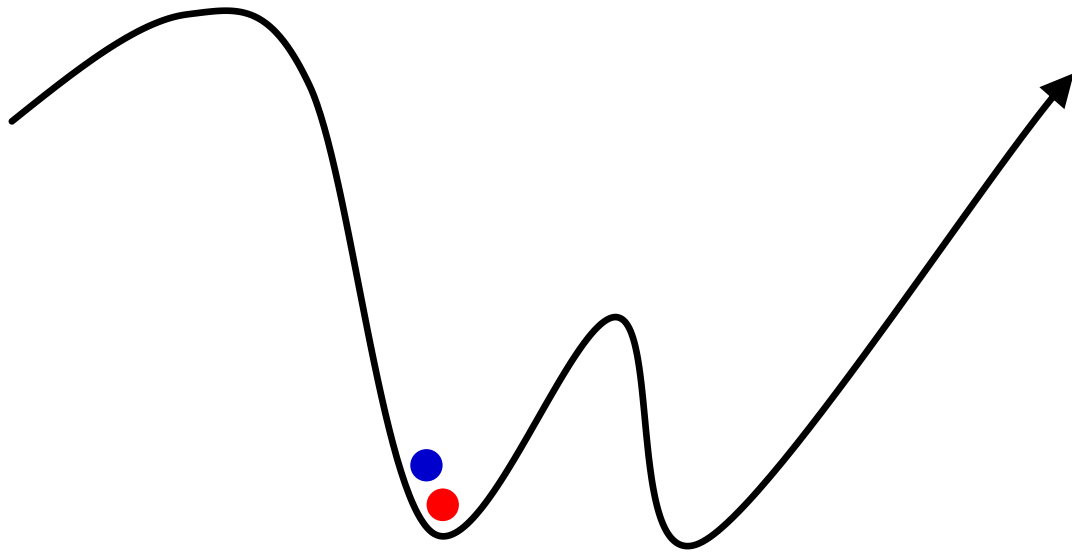


2D tracking

Bootstrapping: 3 Points PnP



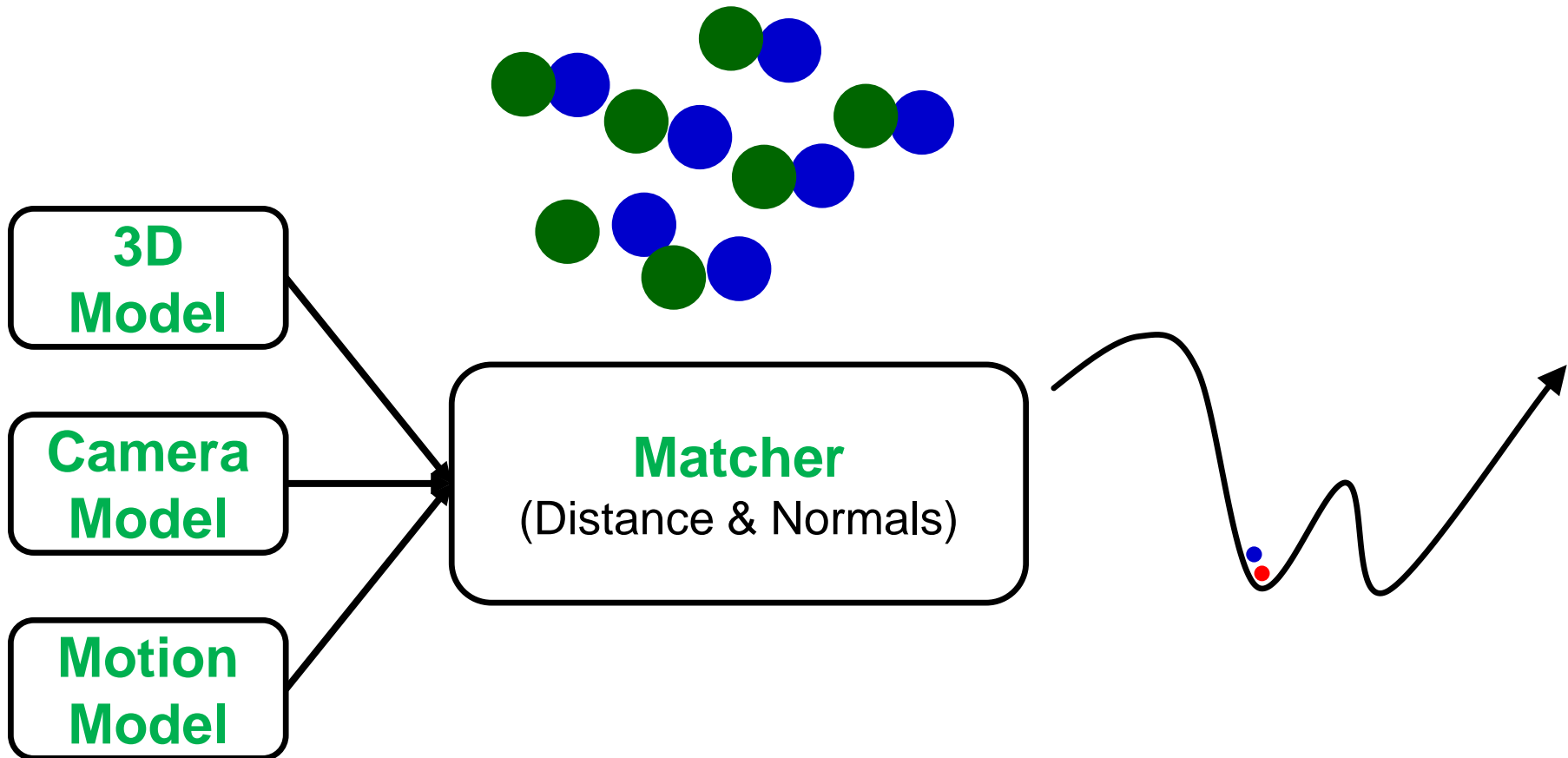
Bootstrapping: PnP Refinement



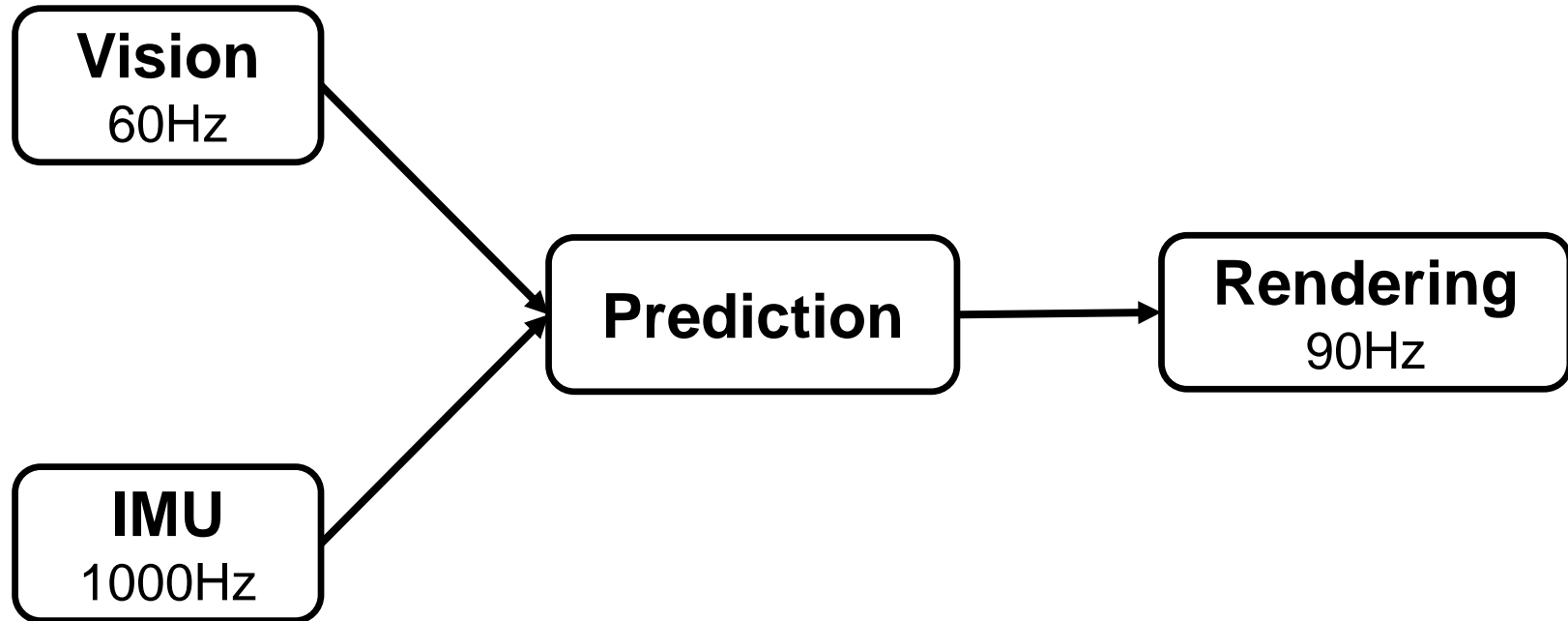
Iterative **Object Space Error** Optimization

Tracking

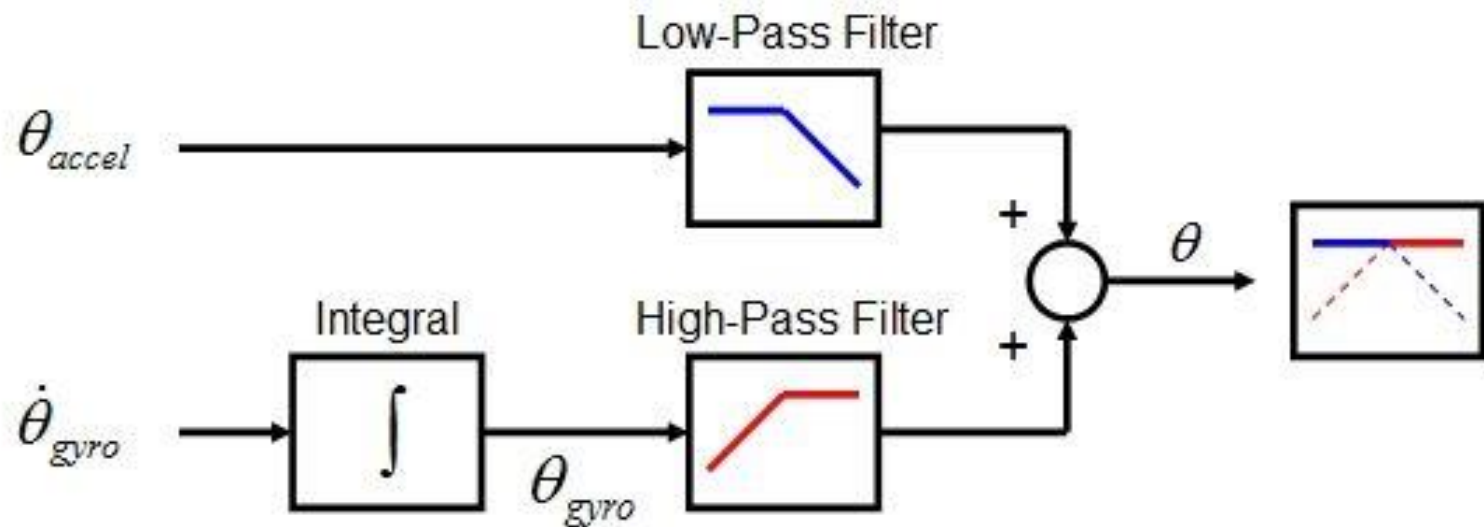
Predict → Match → PnP Refinement



Sensor Fusion

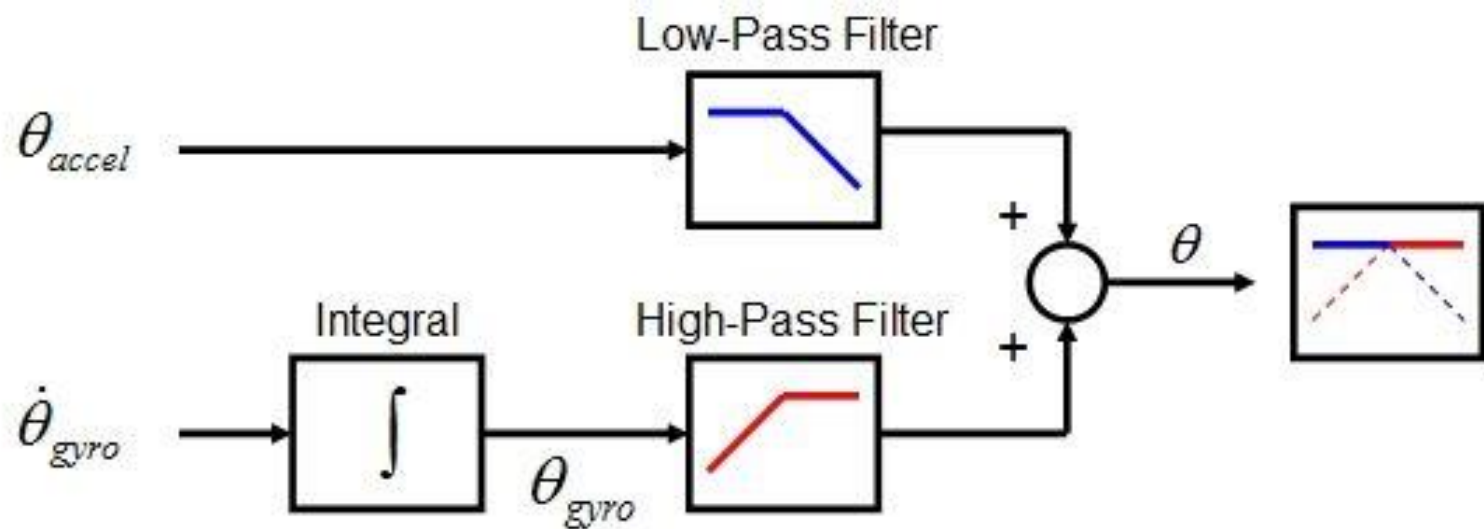


Complementary Filter: Orientation (IMU)



$$\text{orientation} = (\text{orientation} + \text{gyro} * dt) * (1 - \text{gain}) + \text{accelerometer} * \text{gain}$$

Complementary Filter: Orientation (IMU + Vision)



Now θ_{accel} only impacts **Roll** and **Pitch**

Yaw is determined based on orientation from **vision**

Complementary Filter: **Position** (IMU + Vision)

$$err = pos_{camera} - pos_{filter}$$

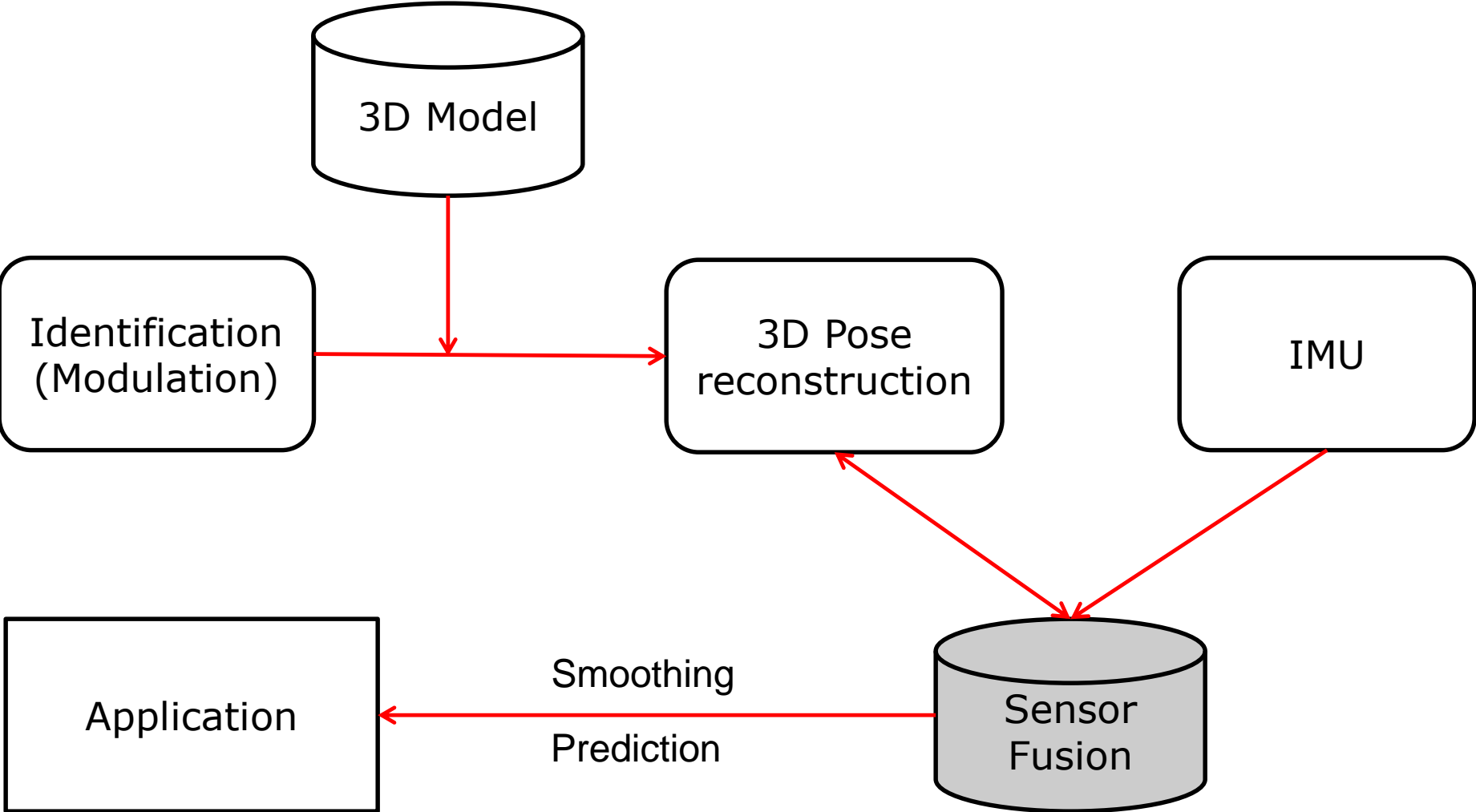
$$pos_{filter} += vel \times \Delta t + err * gain_1$$

$$vel += (accelerometer + bias) \times \Delta t + err * gain_2$$

$$bias += err * gain_3$$

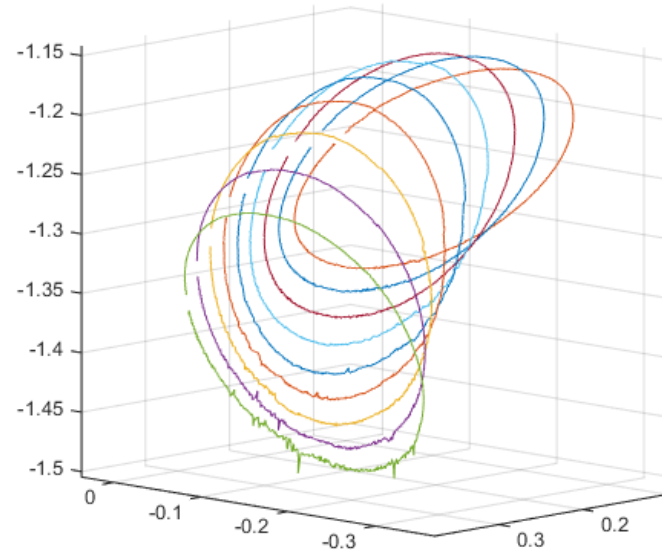
Time stamp data to correlate camera and IMU samples

Prediction & Smoothing



Tracking Quality

- Precision @1.5m:
 - Mean $\sim 0.05\text{mm}$
 - P2P $\ll 1\text{mm}$
- Range: $\sim 2\text{-}2.5\text{m}$
- Latency $\sim 1\text{ms}$ (IMU)
- Vision pipeline $\sim 2\text{ms}$



What's Next: Environment



Object Detection

Dog Detection



Room Modeling



What's Next: User

