

INTRODUCTION OF AUTOMATED-BALL STRIKES

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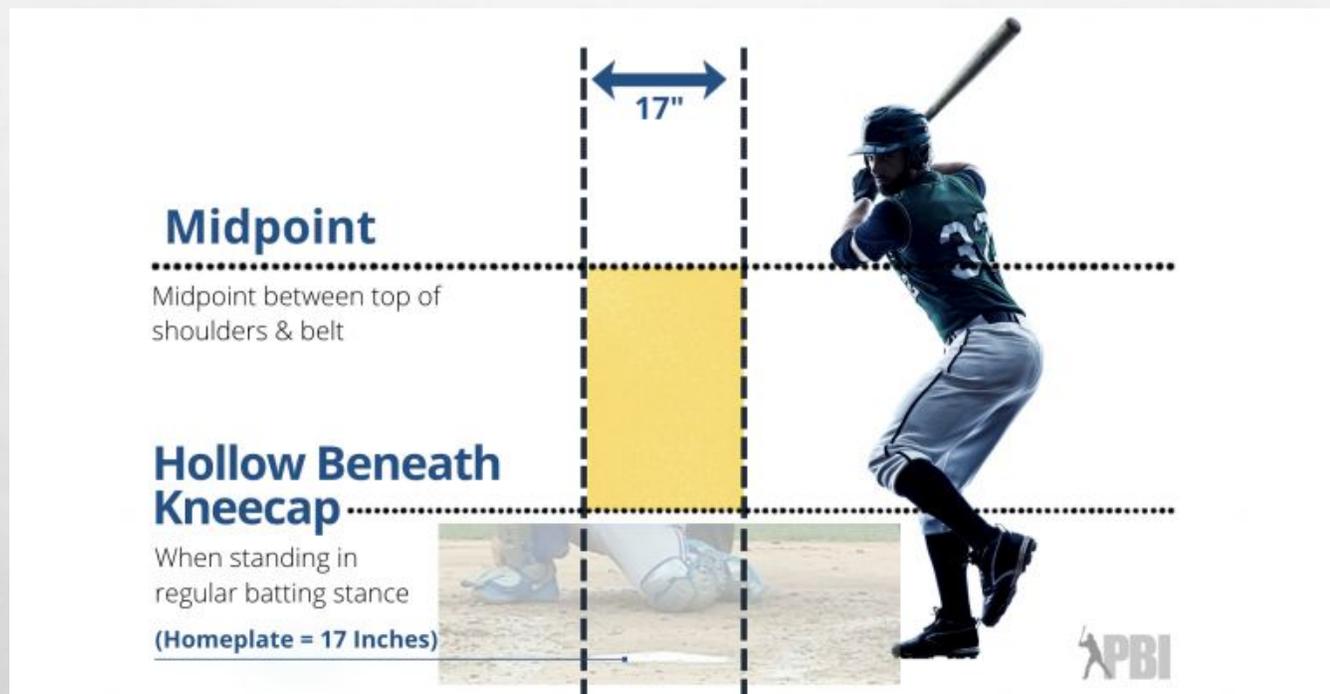
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STRIKE ZONE DEFINITION



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TRACKMAN SYSTEM

□ **USING RADAR SENSOR & HIGH SPEED CAMERA TO DETECT BASEBALL'S:**

- **VELOCITY**
- **SPIN RATE**
- **MOVEMENT**
- **LOCATION**

□ **MORE PRECISE ON LOCATION & MOVEMENT ANALYSIS**

KARMA ZONE

□ USING HIGH SPEED CAMERA TO CAPTURE BASEBALL'S

- MOVEMENT
- LOCATION

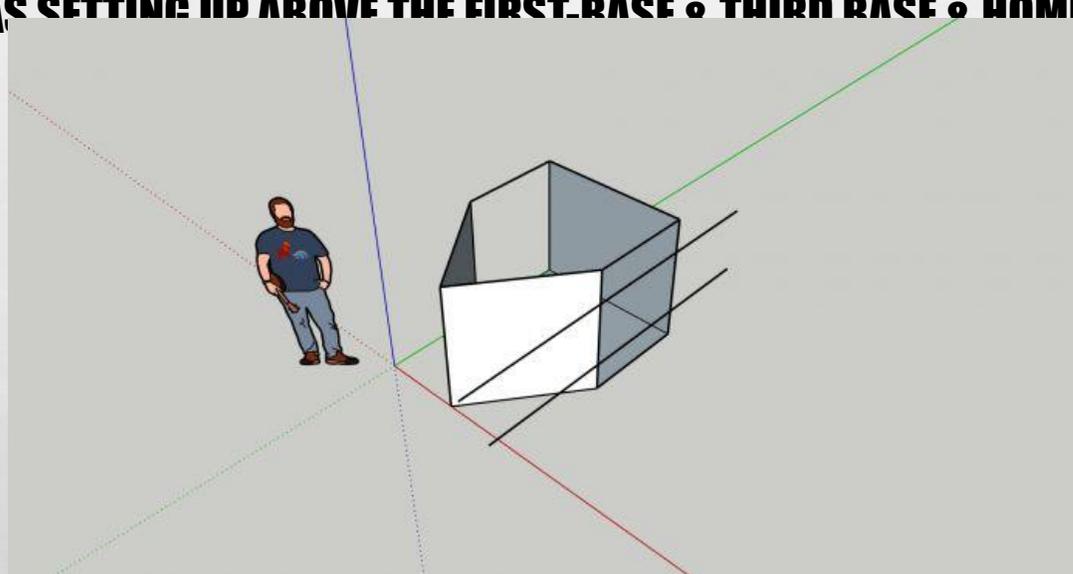
□ AND VISUALIZE THE STRIKE ZONE ON BROADCAST STREAMING THROUGH IMAGE PROCESS & COMPUTER VISION ALGORITHM



PERSPECTIVE PROBLEMS

□ HOW TO RECONSTRUCT 3D COORDINATE IN 2D ?

- HIGH SPEED CAMERAS SETTING UP ABOVE THE FIRST BASE • THIRD BASE • HOME PLATE



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KALMAN FILTER

- **KALMAN FILTER IS AN ALGORITHM USES A SERIES OF MEASUREMENTS OBSERVED OVER TIME, CONTAINING STATISTICAL NOISE AND OTHER INACCURACIES, AND PRODUCES ESTIMATED OF UNKNOWN THAT TEND TO BE MORE ACCURATE THAN THOSE BASE ON A SIGNAL MEASUREMENT ALONE.**
- 1. USE PREDICTED STATE TO CALCULATE PREDICTED MEASUREMENT.**
 - 2. KALMAN FILTER DEALS WITH THE PREDICTION AND MEASUREMENT TO EARN BEST ESTIMATION.**
 - 3. THE STATE ESTIMATION OF KALMAN FILTER INVOLVE THE WEIGHT BETWEEN PREDICTION AND MEASUREMENT (KALMAN GAIN).**

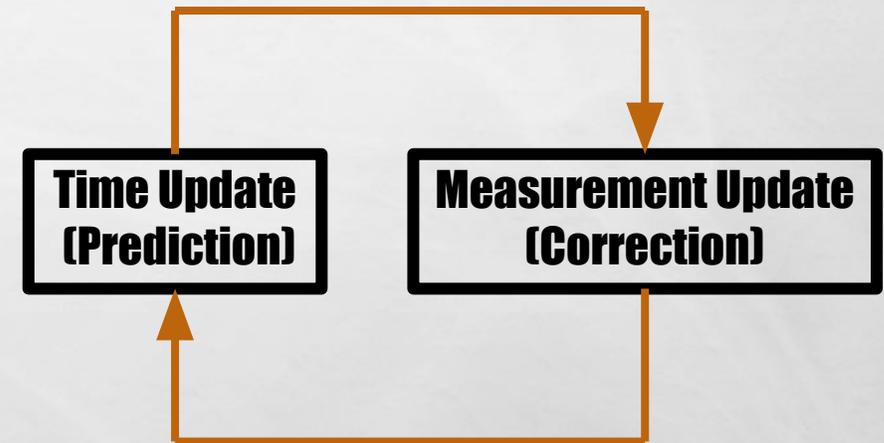
THE STATE-SPACE MODEL

➤ PREDICTION:

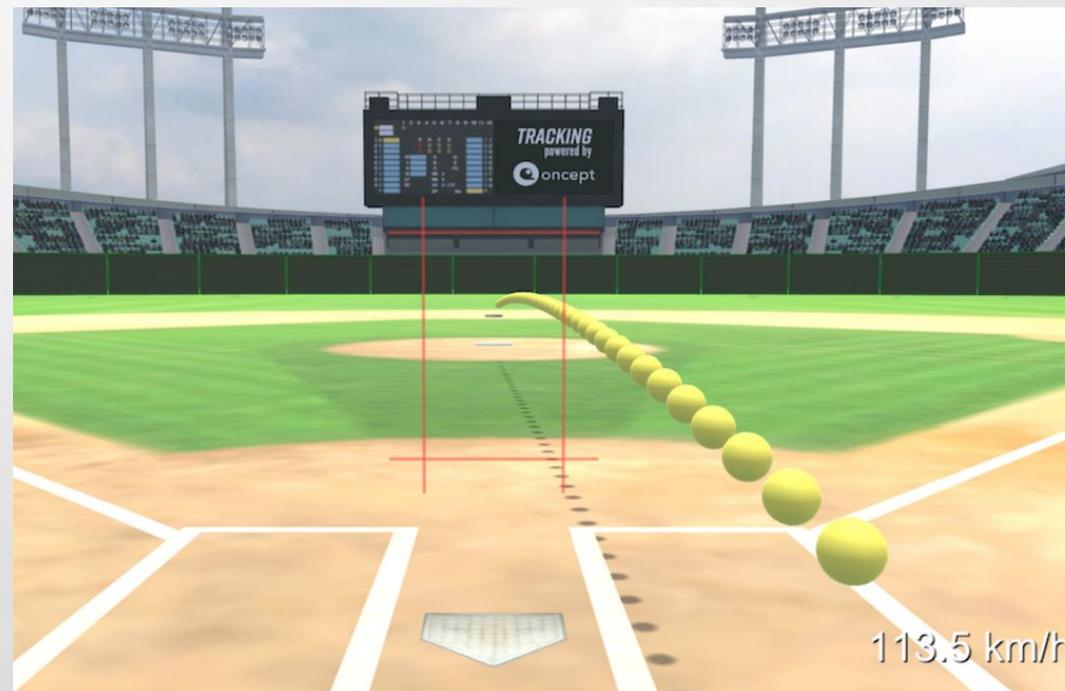
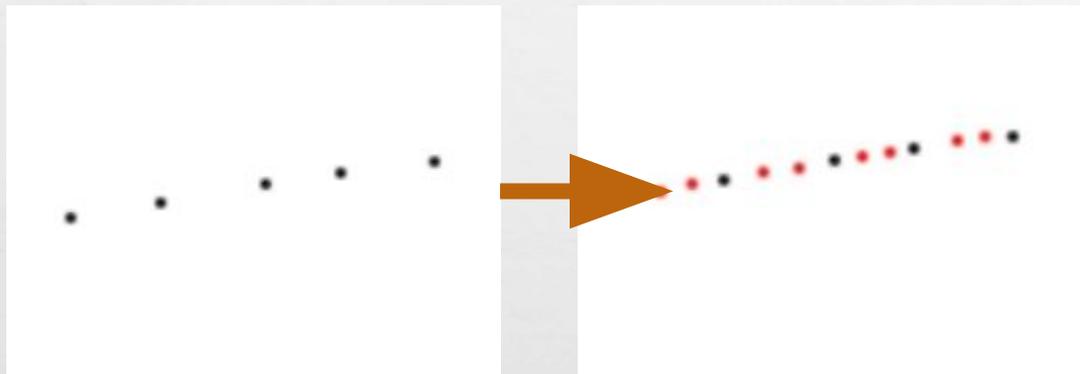
- PROCESS EQUATION: $\mathbf{x}_k = \mathbf{F}_{k-1} \mathbf{x}_{k-1} + \mathbf{u}_k$
- STATE COVARIANCE MATRIX: $\mathbf{P}_k = \mathbf{F}_{k-1} \mathbf{P}_{k-1} \mathbf{F}_{k-1}^T + \mathbf{Q}_k$

➤ MEASUREMENT UPDATE:

- KALMAN GAIN: $\mathbf{K}_k = \mathbf{P}_k \mathbf{H}^T (\mathbf{H} \mathbf{P}_k \mathbf{H}^T + \mathbf{R})^{-1}$
- PREDICTED VALUE: $\hat{\mathbf{x}}_k = \mathbf{x}_k + \mathbf{K}_k (\mathbf{z}_k - \mathbf{H} \mathbf{x}_k)$
- PROCESS NOISE: $\hat{\mathbf{P}}_k = (\mathbf{I} - \mathbf{K}_k \mathbf{H}) \mathbf{P}_k$



BALL TRACKING



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YOLO V4

- **THE BEST OBJECT DETECTION SYSTEM IN 2020**

- **ARCHITECTURE:**

- **INPUT**

- **BACKBONE**

- **NECK**

- **HEAD**

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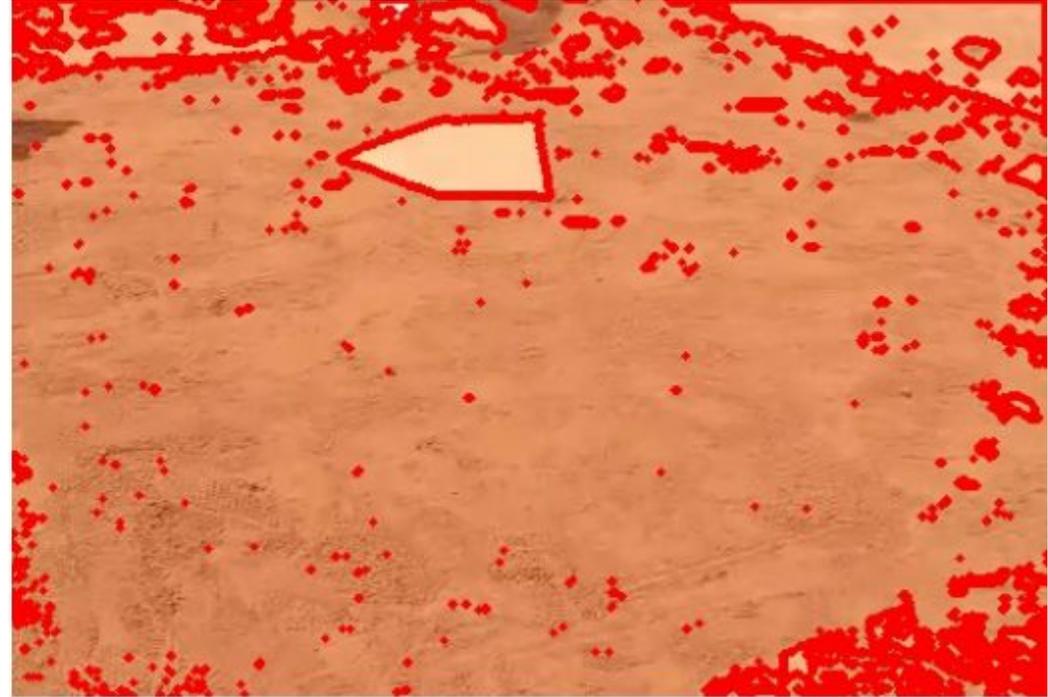
PRE-PROCESSING: CONTRAST ENHANCEMENT



PRE-PROCESSING: BINARIZE



PRE-PROCESSING: HOME-PLATE CONTOUR

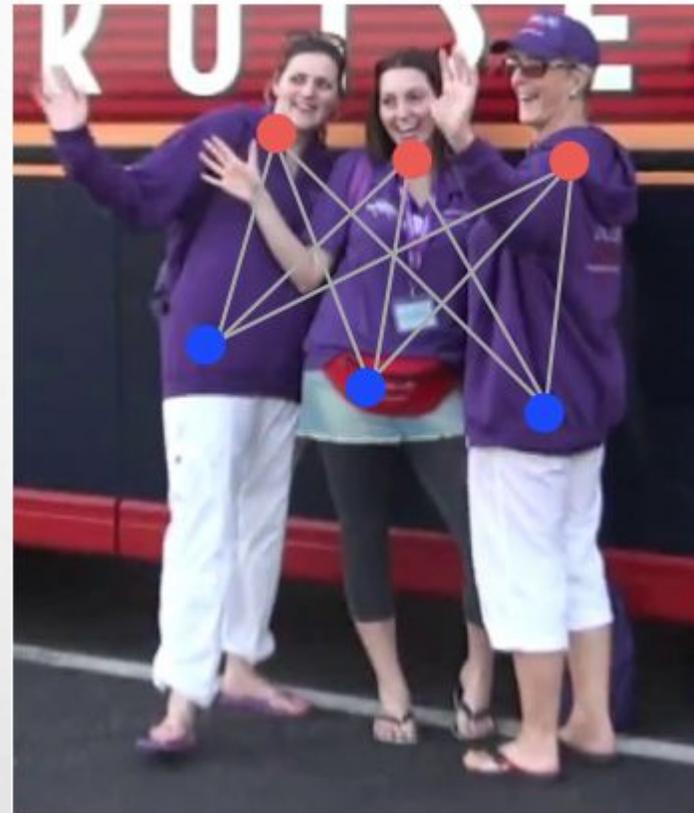


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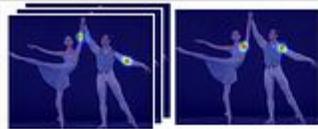
OPENPOSE

Tasks:

- Detect multi-person pose in a frame
- Solve the overlapping problem
- Real-time detection



(a) Input Image



(b) Part Confidence Maps



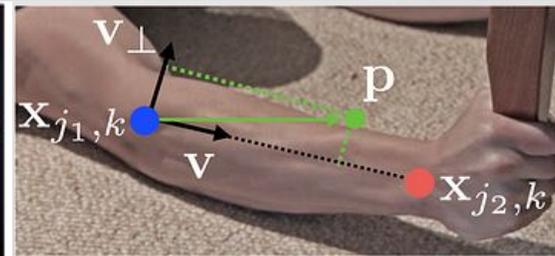
(c) Part Affinity Fields



(d) Bipartite Matching



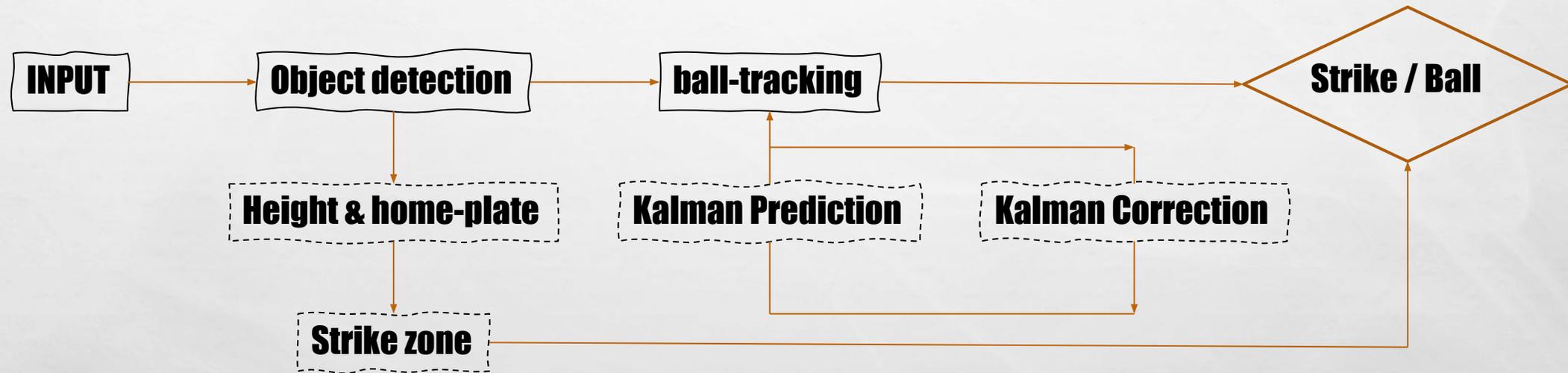
(e) Parsing Results



$$\mathbf{L}_{c,k}^*(\mathbf{p}) = \begin{cases} \mathbf{v} & \text{if } \mathbf{p} \text{ on limb } c, k \\ \mathbf{0} & \text{otherwise.} \end{cases}$$

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BLOCK DIAGRAM



REFERENCE

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