BatVision Pro: Precision Computer Vision Pipeline for Baseball Bat Measurement

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Abstract

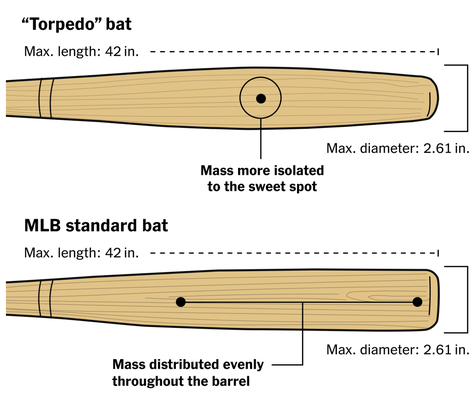
At the Baltimore Orioles' request, we developed a super high-precision computer vision pipeline that produces dimension measurements of any baseball bats.

Our end-to-end solution employs camera calibration, K-means segmentation, geometric calculations, and Machine Learning methods, ultimately achieving a **precision greater than 99.8%**. What's more: the only equipment needed to replicate our pipeline are an iPhone and a clean background!

Objectives

Reliable, high-precision dimension data of existing baseball bats opens the door to many possibilities:

- Equipment quality control;
- Batting performance analytics;
- And even designing unconventional bats that redefine the game! Check out **the Yankee's torpedo bats ⬇**



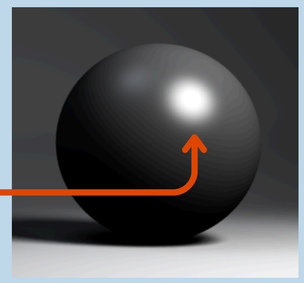
However, traditional Manual measurement lacks accuracy and efficiency, motivating the need for **a scalable, reliable alternative**.

Stages of Our Pipeline

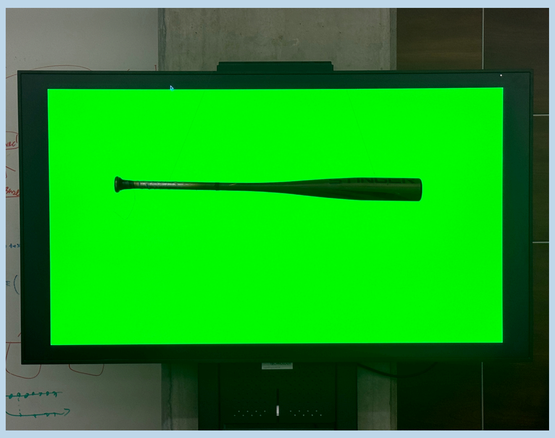
1 Visual Data Collection

What kills precision in computer vision?

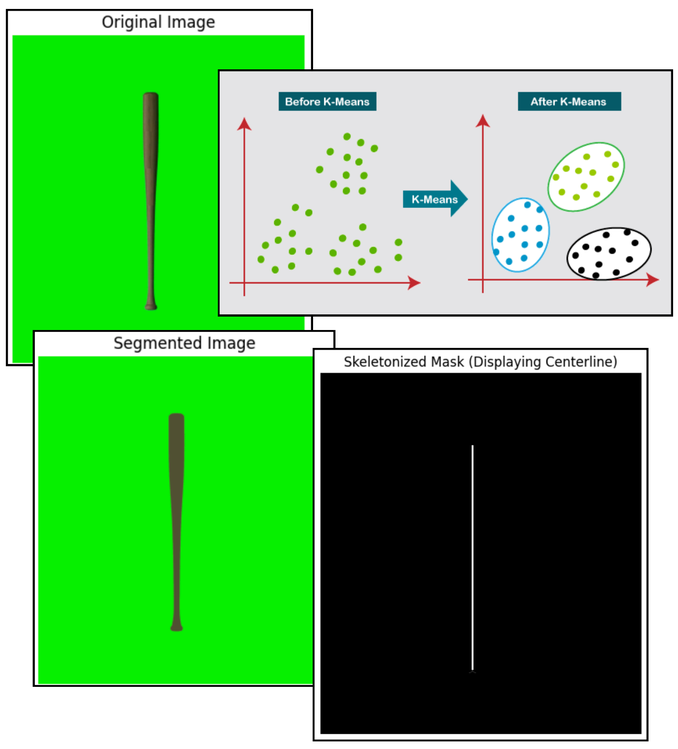
- Uneven background texture
- Specularity
- SHADOW



Our simple yet effective solution? Suspending the bat in front of a **matte TV screen** using **ultra-thin fishing lines**, creating a **uniform, self-lit backdrop**.



2 Image Segmentation & Centerline Detection

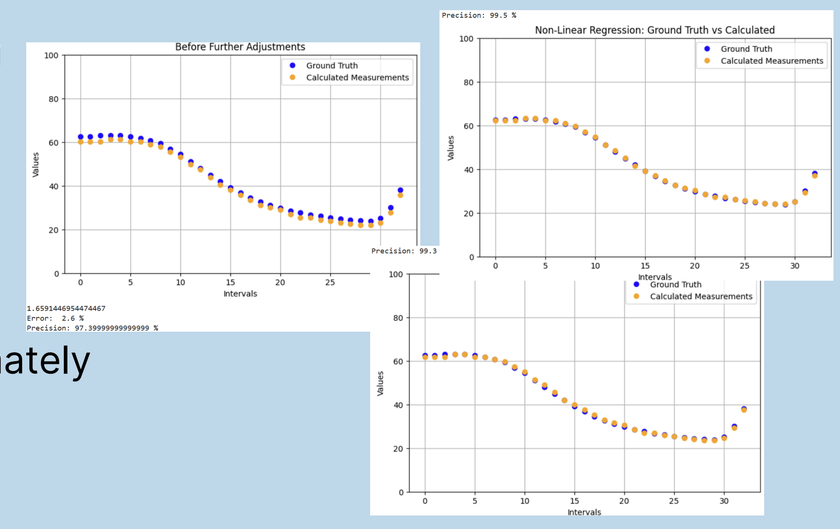


Having experimented with different segmentation techniques, eventually we decided on **K-means Clustering** to separate the bat (foreground) from the background. This unsupervised algorithm grouped pixels based on color similarity.

From the segmented mask, we **detected the bat's centerline**, which we then used to generate perpendicular slices, representing diameters along the bat's length.

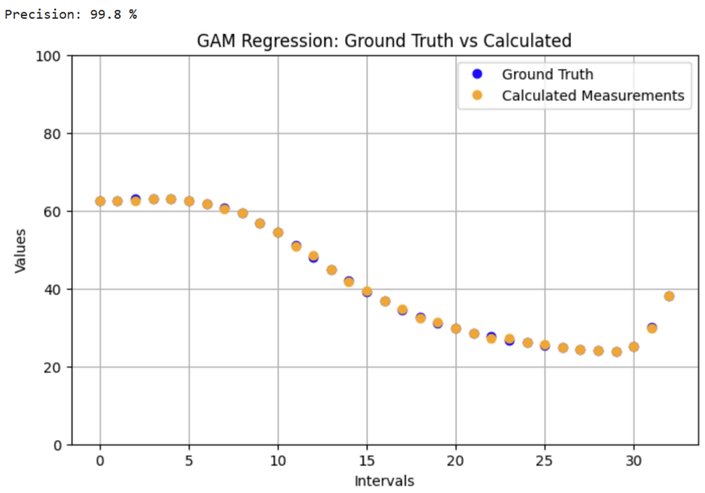
3 Linear & Non-Linear Regression

After predicting bat diameters along the bat's length, we further reduced residual errors by applying both **linear & nonlinear (exponential) regression** methods. These refinements significantly improved precision from approximately **97%** initially to **99.3% (linear)** and **99.5% (exponential)**, respectively.



4 Generalized Additive Models (GAMs)

To further enhance accuracy, we applied a **Generalized Additive Model (GAM)** by segmenting the bat into **four distinct regions** along its length. Each region was individually fitted with a GAM, effectively capturing local shape variations and reducing residual errors. This approach significantly boosted precision, achieving an overall accuracy of **99.8%**.



Curious To See More?

Our research and close collaboration with the Orioles have received media coverage from prominent platforms, including JHU Hub and CBS News.

JHU Hub Feature ⬇

CBS News Feature ⬇