## **Development Documentation of Card Grading & Centering App**

## **1. Project Overview**

### **1.1 Purpose**

The **Card Centering Analyzer** app allows users to take a photo of a trading card (sports, TCG, etc.) against a **dark background**. The app automatically detects the card’s edges, applies a leveling mechanism using the phone’s camera sensors, and calculates centering ratios in an easy-to-read format such as:

* **L|R 56/44 Left: 56 | Right: 44**
* **T|B 49/51 Top: 49 | Bottom: 51**

In addition to centering analysis, the app will provide **estimated grades for centering** based on the grading standards of **PSA, BGS, TAG, and CGC**.

### **1.2 Target Users**

* **Collectors & Graders:** People who want to evaluate their card’s centering before submitting it for professional grading.
* **Resellers:** Those who need quick centering verification for online sales.
* **Grading Enthusiasts:** Users who are interested in centering as a key aspect of card condition.

## **1. Core Features**

### **1.1 Camera-Based Detection**

* Users take a **top-down photo** of a card against a **dark background**.
* **Leveling Guide:** The phone’s gyroscope and accelerometer help align the camera for a flat-lay shot.
* **On-Screen Guides:** A rectangle overlay helps users center the card before capturing the image.
* **Dark Background Enforcement:** Users must place the card on a **dark surface** for the detection algorithm to function properly.

### **1.2 Automatic Centering Analysis**

* **Card Detection:** OpenCV-based edge detection isolates the card from the background.
* **Perspective Correction:** Ensures the card is viewed in a perfect rectangle (removes skew/tilt).
* **Border Measurement:** Detects left, right, top, and bottom border thickness.
* **Centering Calculation:** Computes centering ratios as percentages (e.g., *L|R 56/44, T|B 49/51*).
* **Real-Time Feedback:** Displays centering ratios **immediately** after image capture.

### **1.3 Grading Estimate**

* The app will provide **grading estimates for centering** based on the criteria of:
  + **PSA (Professional Sports Authenticator)**
  + **BGS (Beckett Grading Services)**
  + **TAG (Transparent Authentication Grading)**
  + **CGC (Certified Guaranty Company)**
* The app will cross-reference the centering percentages against each company’s grading scale and estimate what centering **grade the card would receive**.

### **1.4 Manual Edge Adjustment**

* If **automatic detection fails**, users can **manually fine-tune** detected edges.
* A zoomed-in **drag-and-adjust interface** will allow users to correct card borders for more precise measurements.

## **2. Technical Implementation**

### **2.1 Image Processing & Centering Algorithm**

We will use **OpenCV** to perform:

1. **Edge Detection:** Convert image to grayscale and detect contours.
2. **Card Detection:** Identify the largest four-sided contour (assumed to be the card).
3. **Perspective Transform:** Adjust the image so the card is viewed as a perfect rectangle.
4. **Border Analysis:**
   * Scan from each edge inward until a significant color change is detected.
   * Measure left, right, top, and bottom borders.
5. **Centering Calculation:**
   * Compute centering ratio as:
     + **L|R Ratio:** (Left Border / (Left + Right)) \* 100
     + **T|B Ratio:** (Top Border / (Top + Bottom)) \* 100
   * Convert ratios into human-readable format (e.g., **L|R 56/44, T|B 49/51**).
6. **Grading Estimate Algorithm:**
   * Use centering ratios to estimate grading scores:
     + PSA 10 requires **60/40 or better**
     + BGS uses **four separate subgrades**, centering being one of them.
     + TAG provides **detailed digital grading reports**.
     + CGC follows **similar centering standards** to PSA.
   * Convert measurements into a projected **centering grade** for each grading company.
7. **Output the Results:** Display calculated ratios, grading estimates, and a **visual representation** of the card’s centering.

### **2.2 Leveling Assistance**

* **Gyroscope & Accelerometer Data:**
  + Display **tilt indicator** on the camera preview.
  + Notify users if the phone is not level.
* **Overlay Alignment Guide:**
  + Provide a **guide box** to help users frame the card correctly.
  + Use **real-time edge detection** to highlight the card before taking a photo.

### **2.3 Offline Functionality**

* The app should function **100% offline** for all core features.
* If **some technical aspects require online connectivity**, we will prioritize **quality over offline support**.
* Online features may be considered **only if absolutely necessary**.

### **2.4 Cross-Platform Development**

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| --- | --- |
| **Component** | **Technology Recommendation** |
| **Image Processing** | OpenCV (Python, Swift, or Kotlin) |
| **Camera Handling** | Native Camera API (iOS/Android) |
| **Gyroscope Access** | iOS Core Motion, Android Sensors API |
| **Real-Time Edge Detection** | OpenCV Contours, Canny Edge Detection |
| **UI/UX Framework** | Flutter, React Native (for cross-platform support) |
| **Backend (if needed)** | Firebase (optional for analytics) |

## **3. User Experience Flow**

### **Step 1: Open the App**

* User launches the app and sees a camera preview with an **on-screen guide**.

### **Step 2: Align & Capture**

* **Phone leveling indicator** ensures the device is correctly aligned.
* **User aligns the card** with the guide box.
* Edge detection **highlights the card** when recognized.
* User **taps to capture** (or auto-captures when aligned properly).

### **Step 3: Automatic Analysis**

* App **detects the card’s borders**.
* **Calculates centering** ratios in real-time.
* Displays **L|R and T|B percentages** in a clean, simple format.

### **Step 4: Grading Estimate**

* App **estimates centering grades** based on PSA, BGS, TAG, and CGC grading standards.
* Displays potential centering score for each grading company.

### **Step 5: Manual Adjustment (If Needed)**

* If the **auto-detected edges are incorrect**, users can manually adjust them.
* The interface provides **zoomed-in precision controls** to refine measurements.

### **Step 6: Error Handling**

* If centering calculation **fails**, show a message:
  + **“Please retry centering. Use a dark background and remove glare if possible.”**

### **Step 7: View Final Results**

* User sees **instant centering results** and grading estimate.
* Option to **retake the photo** if alignment was off.